For engineers who design and manage the power and plant services

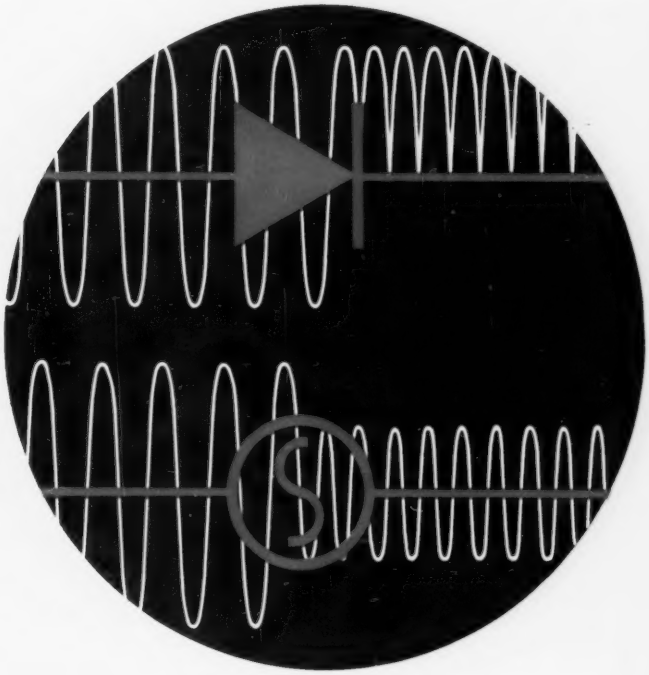
Power

DECEMBER 1959

ONE DOLLAR

A McGRAW-HILL PUBLICATION

Electrical Conversion



A 24-p report on ways to meet the growing need for dc and high-cycle ac. 67

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How to figure mixed-gas behavior 148

Right care for electrostatic precipitators . . . 202

Is your steam hookup a danger source? . . . 205

AEG

The development and supply of electrical equipment for industry has been a vital part of the AEG manufacturing programme ever since this firm was established 75 years ago.

The present AEG manufacture ranges from the industrial turbine to the electronically controlled drive. A "tailor-made" electrical equipment to suit any particular application is the basic requirement for a modern and efficient industrial plant in this age of automation.

AEG
means
ELECTRICITY

8241a

ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT

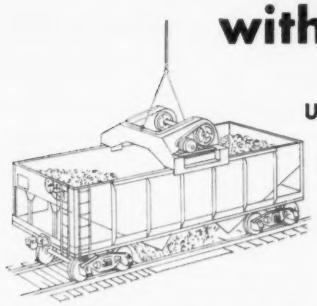
Berlin (West) EXPORT DEPARTMENT Frankfurt (Main)

For more facts circle 201 on Reader Service card, p 123

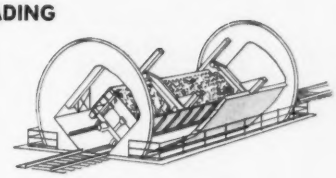
In every phase of coal handling, it pays to

make the move

with LINK-BELT equipment



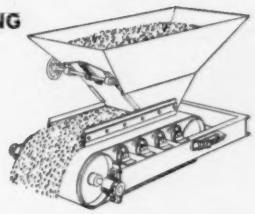
UNLOADING



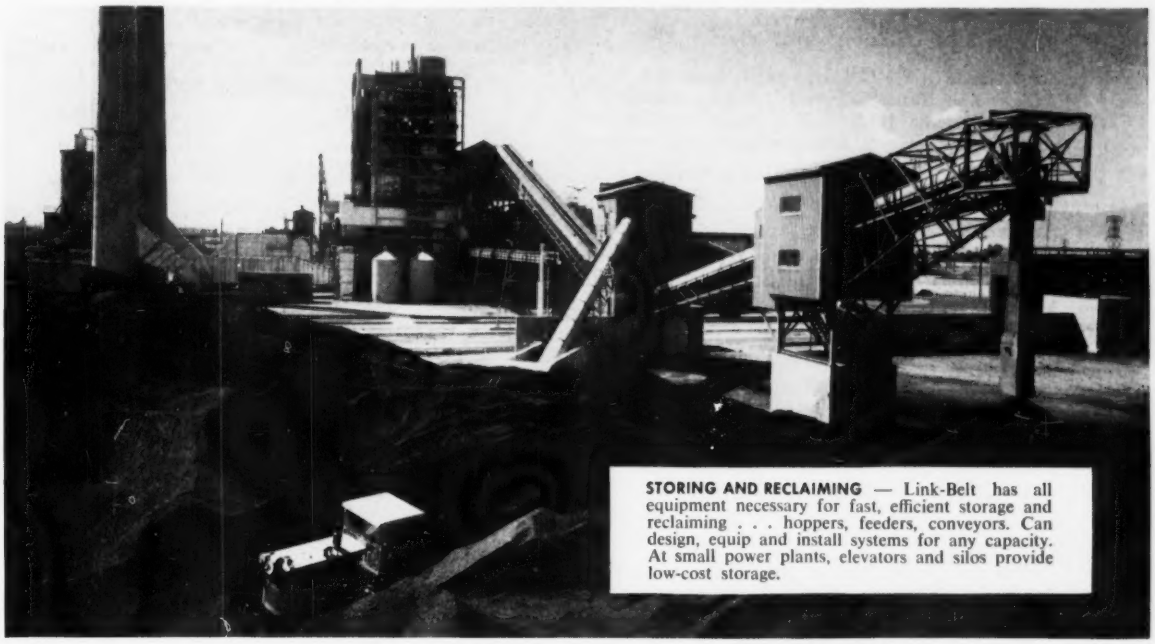
CAR SHAKERS are ideal for small or moderate capacity unloading. Low-frequency vibration is easy on cars . . . positive action cleans hopper-bottom cars fast.

ROTARY DUMPERS unload all types of open-top cars up to ninety-ton capacity. Cars are turned upside down and contents dumped in less than a minute.

FEEDING



FEEDERS for every use are available from Link-Belt. All assure uniformly controlled feed. Broad line includes belt, apron, screw and vibrating types.



STORING AND RECLAIMING — Link-Belt has all equipment necessary for fast, efficient storage and reclaiming . . . hoppers, feeders, conveyors. Can design, equip and install systems for any capacity. At small power plants, elevators and silos provide low-cost storage.

CENTRAL STATION OR SMALL BOILER HOUSE—Link-Belt has equipment for *every* coal handling job. We can furnish components or complete systems to match any capacity, any layout. And, if desired, we will work with your engineers and consultants from planning to erection of your system.

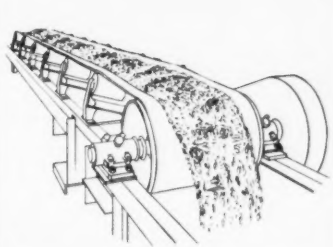
For full details, contact your nearest Link-Belt office. Ask for Book 2410—44 pages of coal handling equipment.

15,202

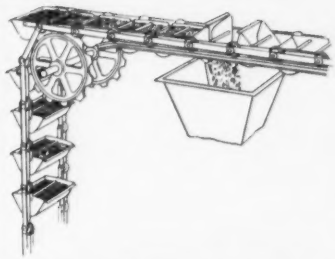
LINK-BELT

COAL HANDLING EQUIPMENT

DISTRIBUTING



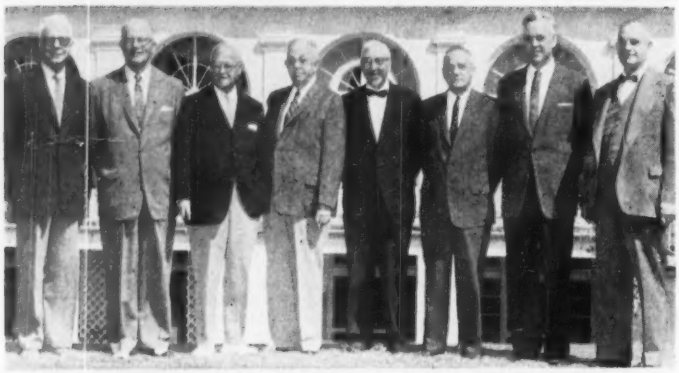
BELT CONVEYORS move large tonnages at low cost—stock out, reclaim, distribute. Link-Belt also builds a full line of idlers, trippers, etc.



PECK CARRIERS elevate and convey in a continuous flow without transfers . . . can travel many combinations of vertical, horizontal, inclined paths.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

speaking of **Power**



Mechanical Packing Assn marks 25th year

MPA counsel George Link Jr; past presidents E L Spence, Anchor; A W Swartz, Linear; J H Maston, Anchor; R M Waples, Garlock; H R Poulson, Johns-Manville; MPA president R B Hazard, Raybestos-Manhattan; secty-treasurer Fred H Luhrs

Anniversaries are almost invariably occasions for looking back over the record. But for progressive organizations they also focus attention on the future. At its Greenbrier meeting, the Mechanical Packing Association did both.

Pictured above are the packing-industry executives who told the 25-year story of MPA's growth and activities in collecting and disseminating information and in developing standards and specifications for various types of packings and seals.

A major forward move was the authorization of a mechanical-packing handbook to present factual information of value to packing users. We on POWER are pleased that we were selected to publish this handbook for the Association, and particularly pleased that a feature will be inclusion of the four special reports by Associate Editor Steve Elonka that comprise POWER's *Basic Data on Seals.*

Lon Rowley

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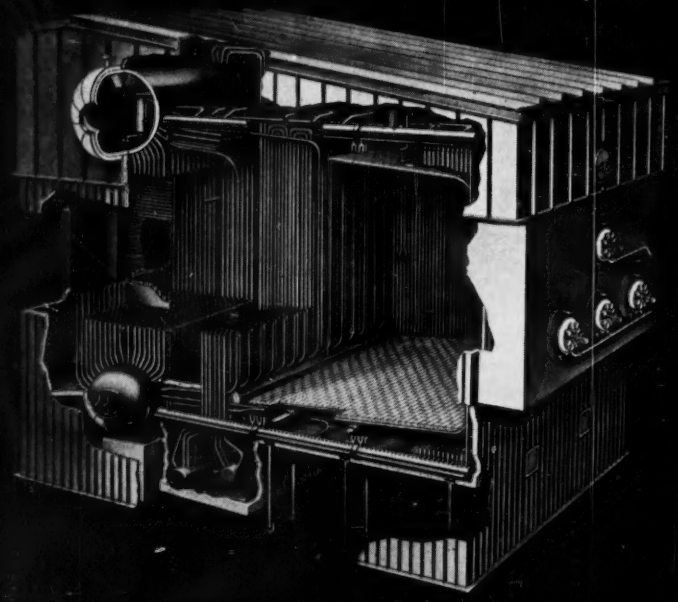
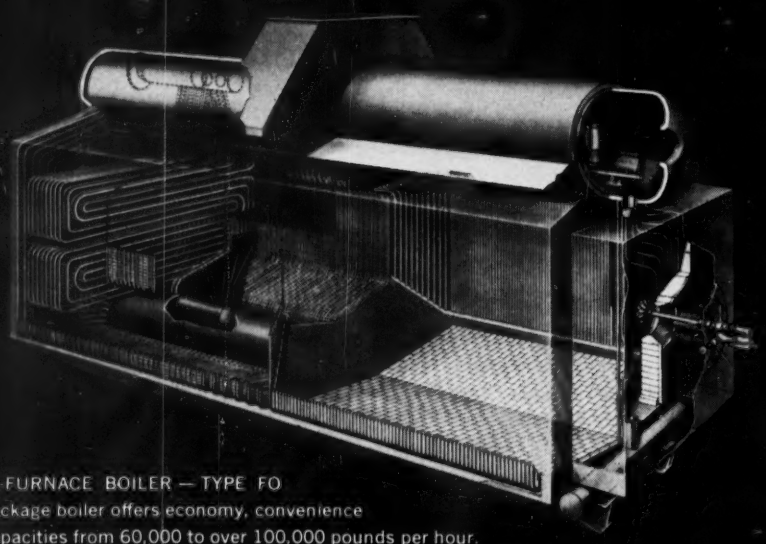
B&W INTEGRAL-FURNACE BOILERS

. . . range in size from shop assembled "package" units (5,000 to 100,000 lb hr) to field erected units for capacities up to 400,000 lb hr.

B&W INTEGRAL-FURNACE BOILER, TYPE PFI—The PFI, B&W's new Integral-Furnace Boiler, produces steam in the general range of 80,000 to 400,000 pounds per hour. Oil or gas, or a combination of both, can be used as fuel. In power, process or heating applications, the pressure fired PFI assures clean, dependable steam over a wide load range. The drainable superheater, at left center, permits the draining of water after a shut down, facilitating easy storage and simple, safe start-up. Generous tube spacing prevents ash or slag pluggage of the superheater. The burners at extreme right are centralized for easy observation and adjustment, while the integral combustion air duct at the top of the unit saves space.





B&W INTEGRAL-FURNACE BOILER — TYPE FO — B&W's new package boiler offers economy, convenience and quality at capacities from 60,000 to over 100,000 pounds per hour. A natural circulation boiler, the FO combines the advantages of the package boiler with the proved reliability of B&W Integral-Furnace design. The FO Boiler has a completely water-cooled furnace of ample volume, and is designed to provide steam at pressures from 250 to 775 psi at temperatures up to 750 F.

STEAM FOR INDUSTRY

...from Babcock & Wilcox Integral-Furnace® Boilers.

Steam for industry can be produced most efficiently with units designed and constructed by Babcock & Wilcox, the nation's most experienced company in its field.

B&W's engineering progress provides a range of steam capacities, pressures and temperatures that can solve your particular requirements. Modern B&W Integral-Furnace Boilers embody the operation, design and maintenance features that assure efficiency, economy and availability of clean, dry steam for any use.

For new plant installation, expansion of present facilities or replacement of obsolete units, ask B&W's engineering staff for their recommendations. They'll be happy to help you work out the best solution. The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

G-957-1B

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THE BABCOCK & WILCOX COMPANY

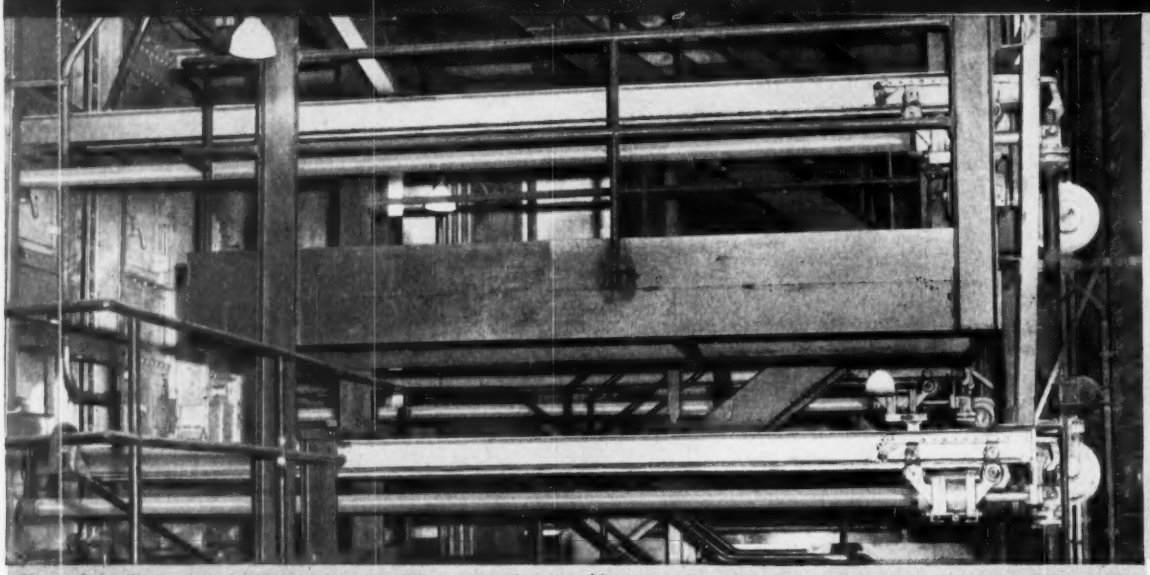
BOILER DIVISION

AT F.M. TAIT STATION, DAYTON POWER & LIGHT CO.

BOILER CLEANING IMPROVEMENT HELPS MODERNIZATION PROGRAM

SAVE $40,000

DIAMOND BLOWERS and AUTOMATIC



Three of the Diamond Model IK Long Retracting Blowers installed to replace manually operated rotary blowers. Electric motor driven, they are controlled by the Automatic Sequential Panel. Air is used as the blowing medium. Rotary elements were retained in cooler locations and motorized for automatic operation and are also controlled by the Automatic Sequential Panel.

In the continuous struggle to cut operating costs, the Dayton Power & Light Co. has found a very useful tool in "Boiler Cleaning Modernization."

By applying the latest soot blowing equipment to four of their boilers at the F. M. Tait Station, together with other features of the modernization program, the Dayton Power & Light Co. was able to reduce the operating costs on these boilers by some $40,000 per year and also cut blower maintenance costs.

On the first boiler that had its cleaning modernized, 17 rotating elements were removed; the remaining seven blowers of this type were electrified for automatic control. The cleaning equipment added consisted of five Long Retracting Blowers and six Short Retracting Blowers. All blowers are automatically controlled by a Diamond Selectromatic Panel.

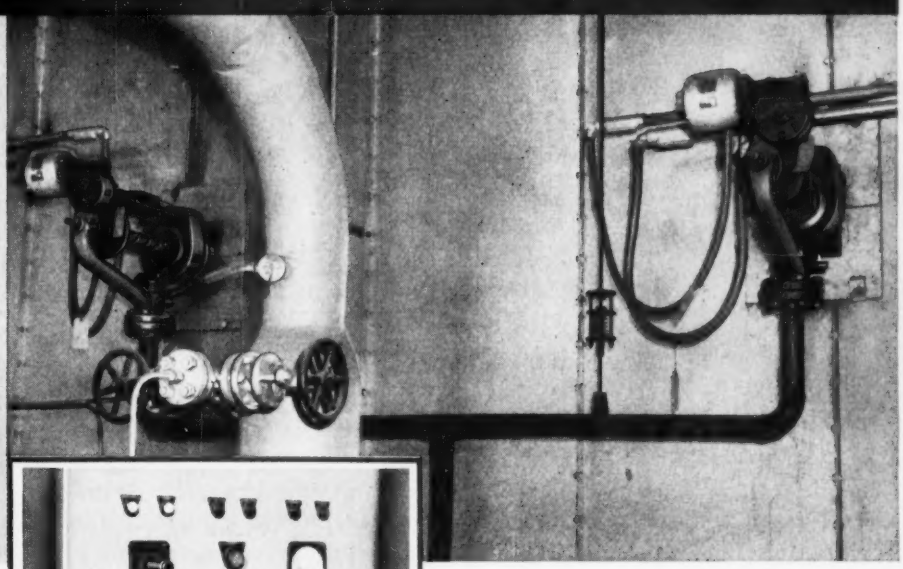
This is one of many examples of the savings possible by improvements now available in Diamond Blowers and Automatic Sequential Control. Over the years Diamond has engaged in continuous aggressive research in boiler cleaning. This research has paid off in improvements that save you money and improve your operation.

Let us make a study of your boiler cleaning . . . perhaps similar savings can be suggested.

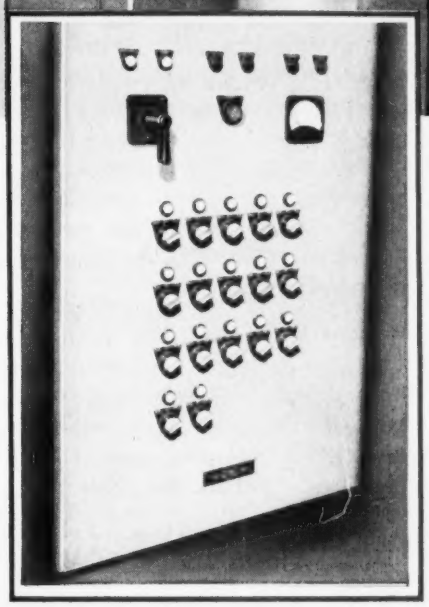
Per Year in Operation

and Cut Blower Maintenance Costs

SEQUENTIAL CONTROL PANEL



Two of the air blowing Model IR short retracting wall blowers with electric automatic operation.



Diamond Automatic Sequential Control Panel installed as part of the modernization program at the F. M. Tait Station. This panel automatically operates each blower in turn until the blowing cycle is complete. Any individual blower may be operated independently by simple turning switches. Cleaning program is set up by switches. Operator starts — thenceforth operation is automatic.

DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO

8243

DIAMOND SPECIALTY LIMITED • WINDSOR, ONTARIO

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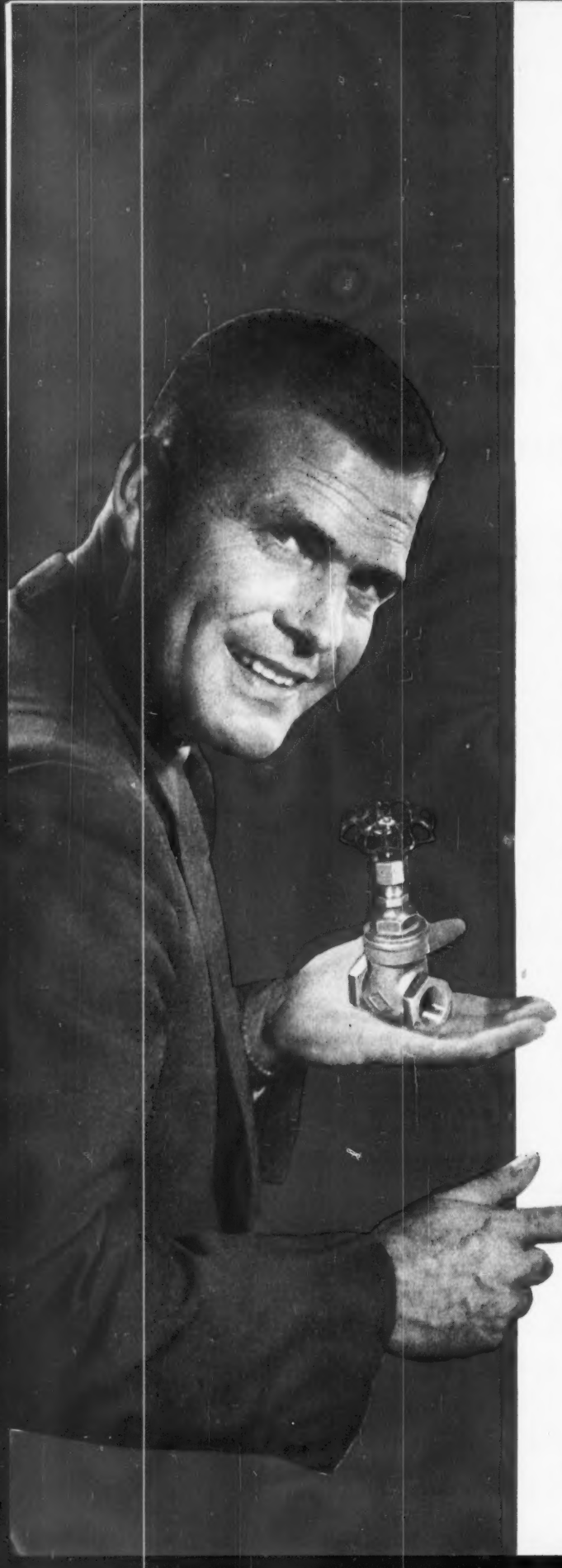

For 99 out of 100...

Selection of

can be as simple as selection of Bronze and Iron Valves

HOW to keep it simple? Don't let the wide selection of stainless steel alloys "throw you"!

Most of the alloy specs were developed to meet certain highly specialized and rather uncommon needs. Only 1 out of 100 valve users can make practical use of many of the alloys. *Actually, just two or three of the different available alloys will give a big majority of valve users all they want and need.*

You can judge DESIGN differences between the various "makes" exactly as you do it with Bronze and Iron valves. Look them over and compare. Basically, of course, a Stainless Steel valve is designed and constructed very much like other valves.

What is left to worry about in addition to Material and Design? The same factors you consider in buying ANY valves for long, dependable performance: Are the valves made merely good enough, or to a standard that demands an extra-measure of quality? How good are the castings? How precise and perfect is the machining? How rigid is the inspection and testing during manufacture? These are the factors which specs can't cover. Some of them you can't see when you look at the valve. But you KNOW how to make sure they measure-up to peak standards. You know that the name JENKINS VALVES and the famous Jenkins DIAMOND trademark have been the highest assurance of quality for nearly a century.

Specify *"Jenkins"* as well as the metal alloy to assure fullest satisfaction. Your Jenkins Distributor has patterns and alloys to satisfy most industrial needs. Of course, they meet valve industry specifications and the high standards established by leading users of stainless steel valves. Jenkins Bros., 100 Park Ave., New York 17.

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JENKINS SINCE 1864

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Stainless Steel Valves

☐ Send the new stainless steel valve catalog

☐ Have a representative call on me

TEAR OFF AND MAIL

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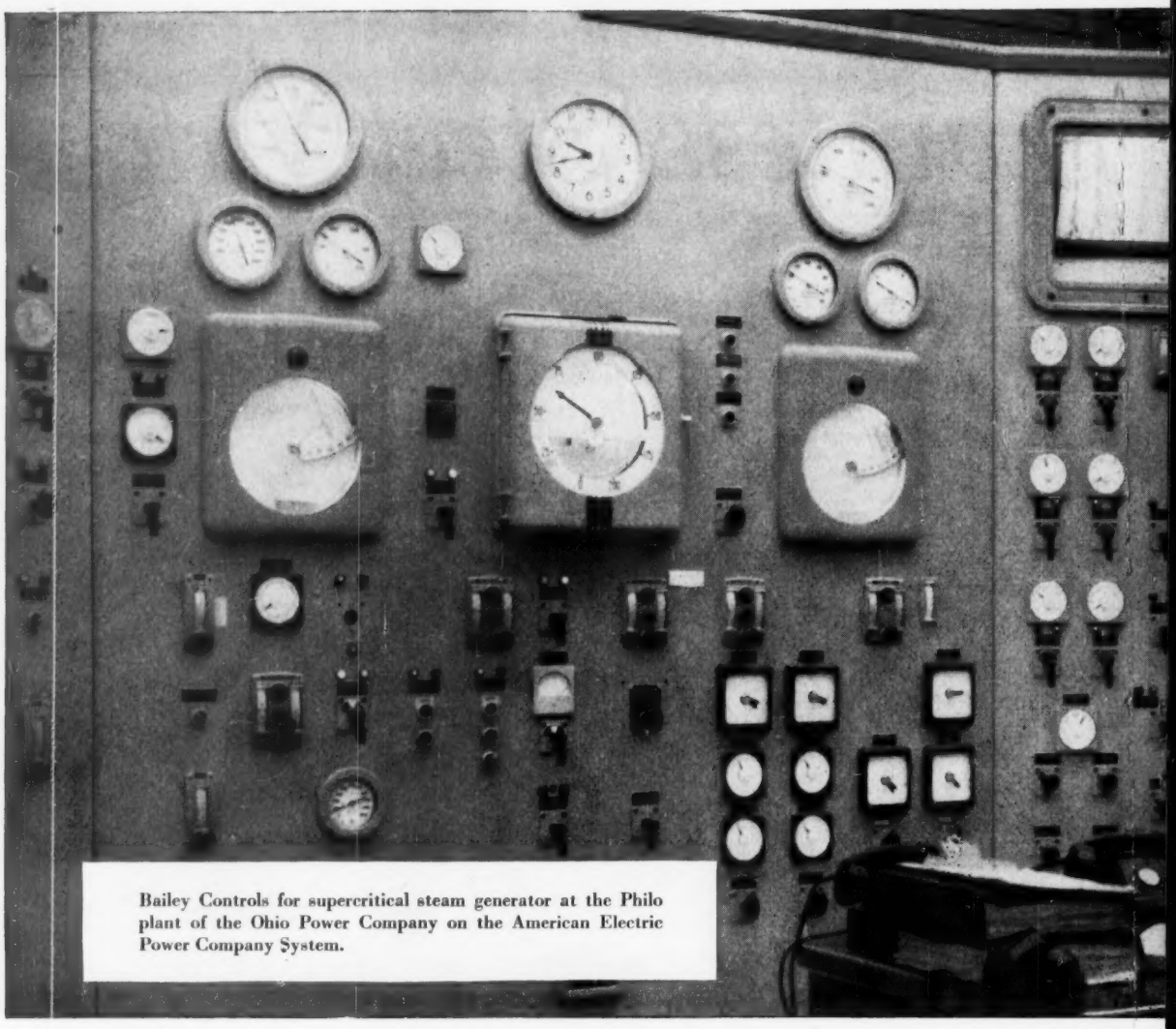


Bailey Controls for supercritical steam generator at the Philo plant of the Ohio Power Company on the American Electric Power Company System.

Bailey pioneers the control of...

This is the control center for the first commercial supercritical pressure, steam-electric unit in America. It went into operation March 20, 1957. Tests made during the first year of operation indicate that this new high pressure unit, with Bailey Controls, is establishing new efficiency records in the conversion of coal to electricity.

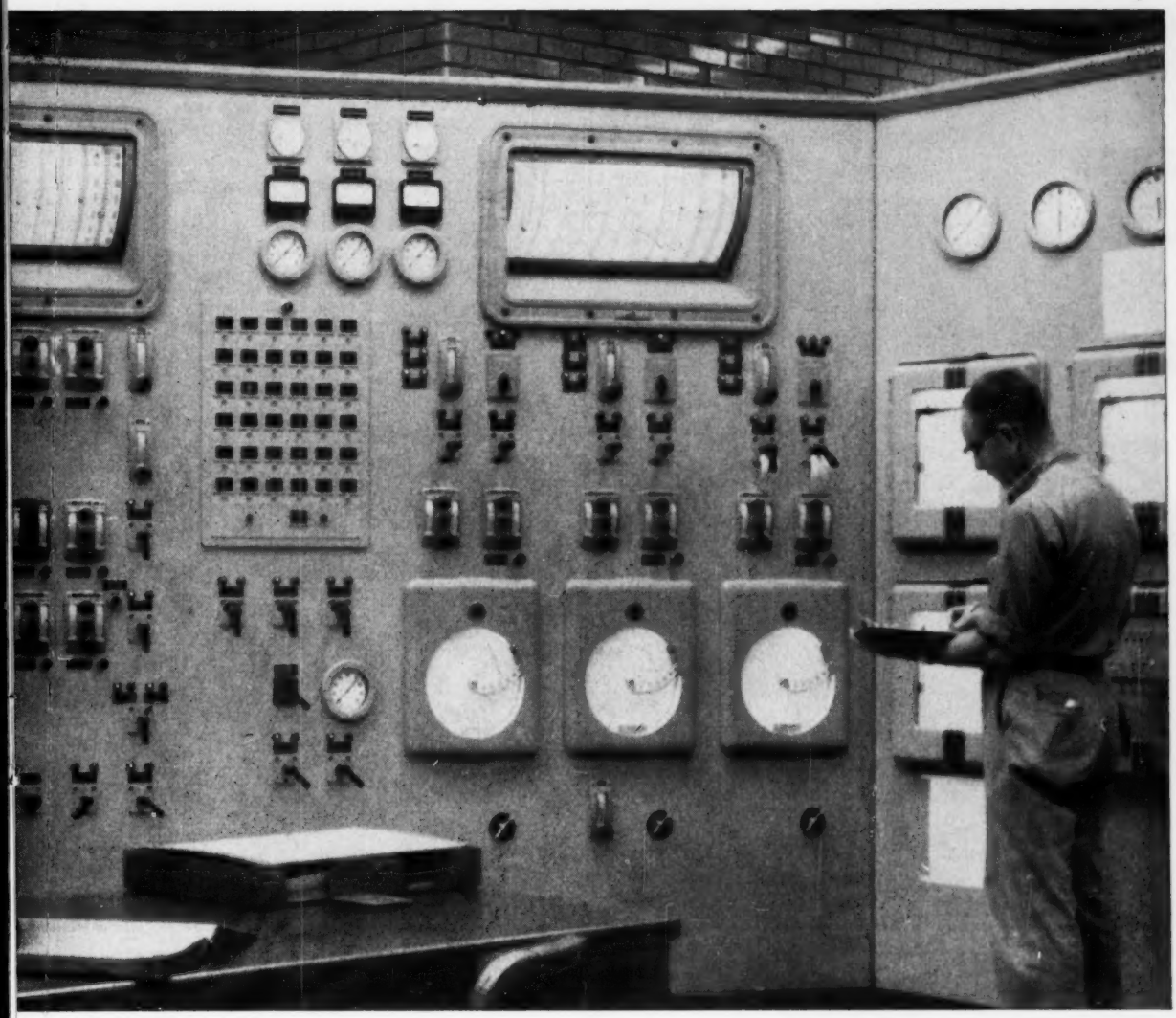
How it works

"Once-through" steam generating units must have radically different control systems from those used on drum-type boilers. At Philo, for instance, the Bailey Control for the 4500 psi, 1150F unit, maintains the desired rate of steam generation by means of a feed water flow controller which regulates feed-pump speed.

In normal operation this controller is set for a constant rate, and boiler outlet pressure is held to the desired value by automatic regulation of the turbine control valves.

An alternative operating method uses the turbine speed governor to regulate turbine control valves and varies feed water flow to maintain boiler outlet pressure.

With either method firing rate is varied to maintain final steam temperature. The Bailey System does this by regulating coal and air in parallel, primarily from changes in feed water flow with secondary adjustments, when necessary, from steam temperature.



SUPERCRITICAL STEAM PLANTS

Optimum combustion conditions are maintained by Bailey Oxygen-Combustibles Recorder-Controllers which continuously sample exit gases from each cyclone and automatically adjust coal feeder speeds.

Seasoned Engineering Experience

For greater fuel savings, less outage and safer working conditions, you owe it to yourself to investigate Bailey Controls. And, for your convenience (and to save time and travel expense) there's a Bailey District Office or Resident Engineer in or close to your industrial community.

Arrange to visit a nearby Bailey installation. We stand on our record. AI35-2

Instruments and controls for power and process

BAILEY METER COMPANY

1036 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

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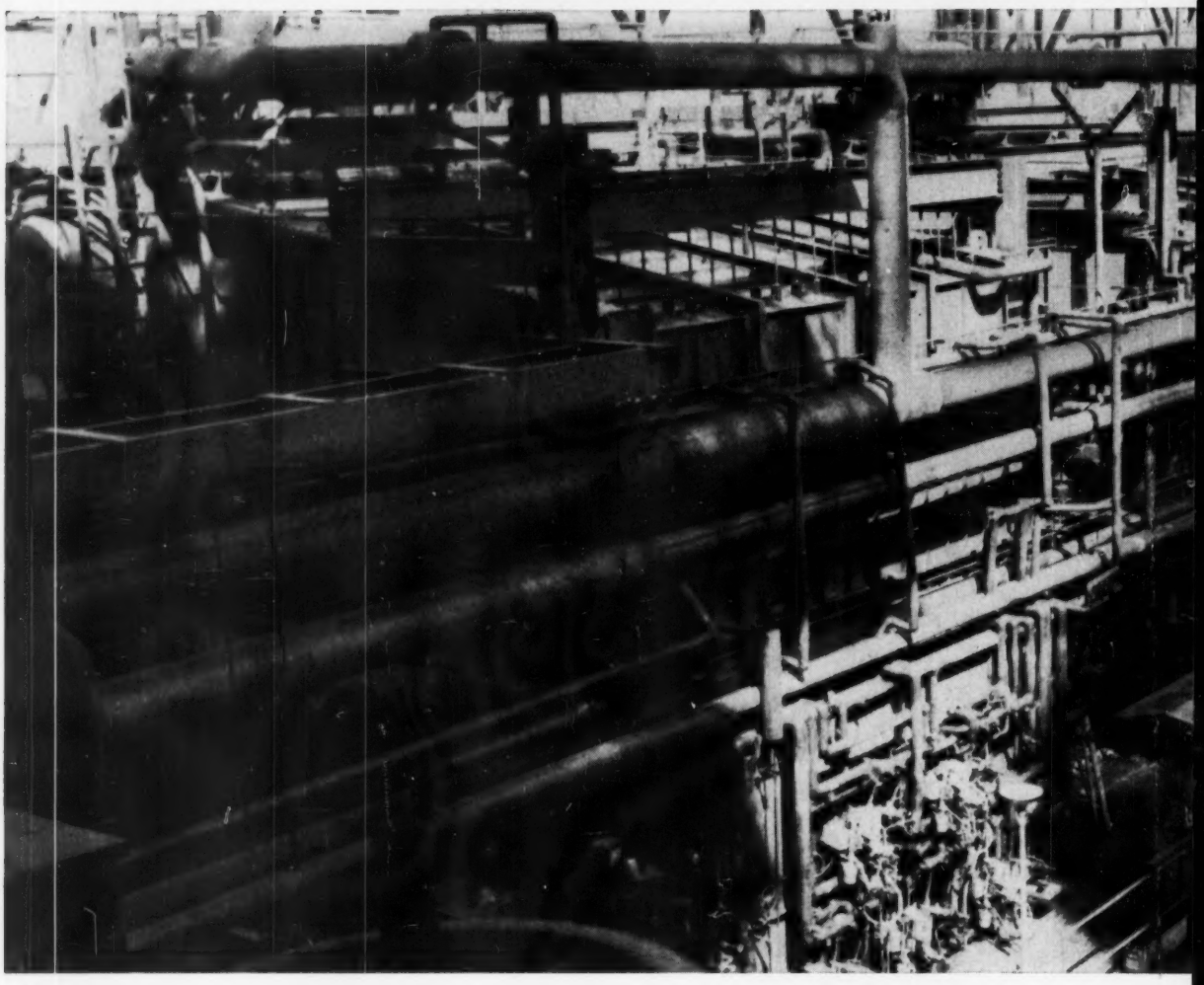


Copes-Vulcan boiler control load conditions at Deepwater

In addition to producing power for the Atlantic City Electric Company system, the Deepwater plant delivers steam to an adjacent chemical plant for process use.

To meet the widely fluctuating process demands, Copes-Vulcan controls the two low pressure boilers with precision responsiveness. Each boiler has a maximum continuous rating of 150,000 pounds per hour at 230 psig saturated. The system consists of:

Combustion Control maintaining a constant pressure in the main process steam header by holding steam output from the boiler equal to steam demand.

Copes-Type 3-L Feedwater Control modulated by three control influences—steam flow, feedwater flow and drum water level.

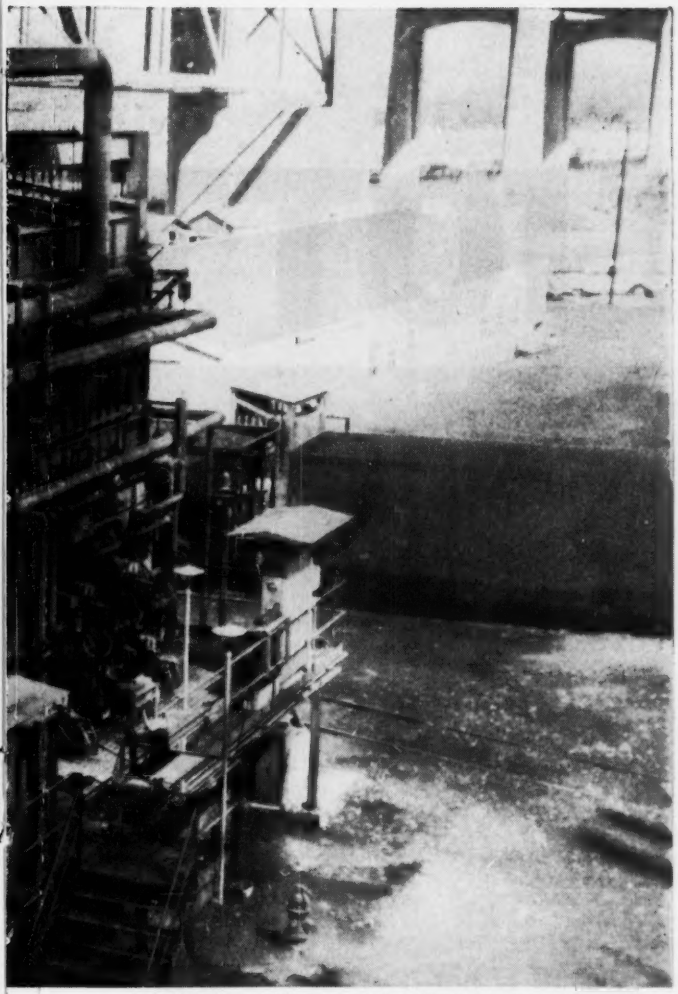
Boiler feed pump recirculation control protecting the boiler feed pumps against overheating on light loads.

Vulcan Rotary Soot Blowers providing positive cleaning over the full blower arc, which may be as much as 360 degrees.

The system controls all equipment with either one or two boilers in service, permits each boiler to carry a different load. Control is automatic through a load range of 20,000 to 200,000 pounds per hour.

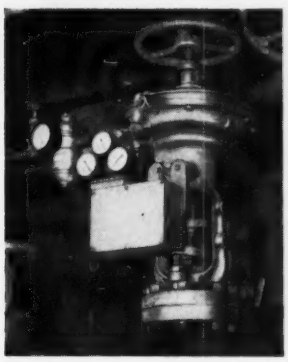
Whether your boiler is large or small, power or process, Copes-Vulcan can provide a unit or an integrated package, custom designed to your requirements. **For details on the Deepwater Station installation, write for Bulletin 1057.**

Copes-Vulcan Division
BLAW-KNOX COMPANY • Erie 4, Pennsylvania



Outside boilers and boiler controls subject to severe weather, with temperatures as low as 10° F. Except for the central control panel and relays and controllers mounted on it, the Copes-Vulcan control system is entirely outdoors.

meets unusual Station

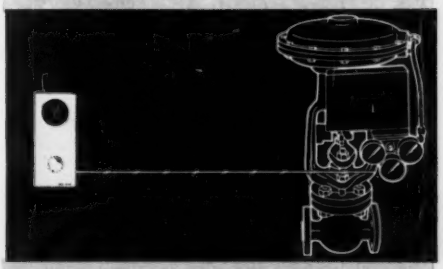


Diaphragm-operated CV-D valve controls the speed of the turbine driving the forced-draft fan. Copes-Vulcan also makes piston-actuated valves. Both types meet pressure standards of 125 to 2500 pounds.

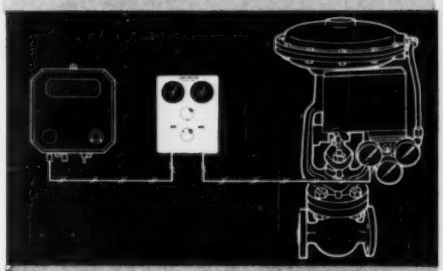
The drive unit with positioner, 4-way valve, power piston and feedback cam controls forced-draft damper. C-V drive units permit remote positioning by automatic or manual pneumatic signals.

C-V NEWS NOTES

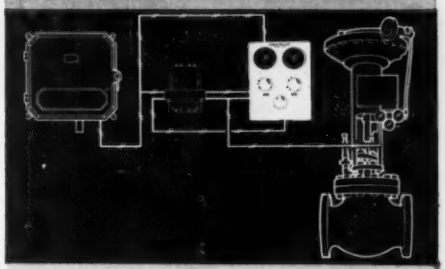
PNEUMATIC CONTROL STATIONS



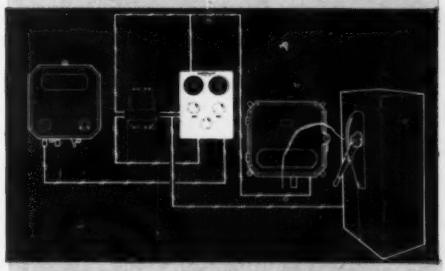
Copes-Vulcan stations offer automatic-to-manual selection without the complication of seal balance. They indicate process-variable, controller and manual loadings. Transfer is "bumpless" without process disturbance. **Shown above: the ML-4 Manual Loading Station.**



AM-4 Selector Station . . . indicates an automatic loading—or originates a manual loading—to the valve, power cylinder or other control element.



AMS-4 Remote Set Station permits manually adjustable set-point loading, or independent manual operation, of the control element.



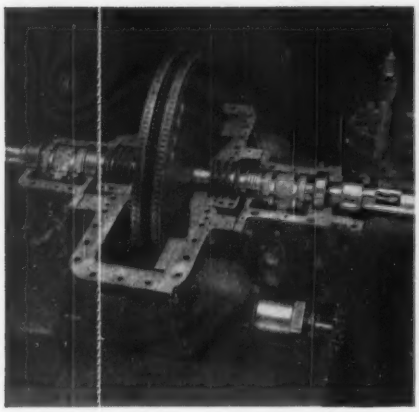
AMBC-4 Cascade Biasing Station, used with pneumatic stacked diaphragm controllers, permits plus-or-minus biasing of a cascaded set-point to the controller.

For details about Copes-Vulcan's complete line of pneumatic control stations, write for Bulletin 1031.

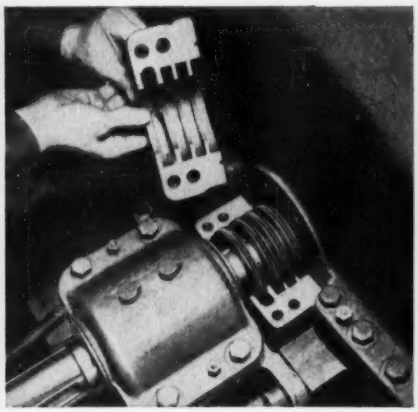
For more facts circle 209 on Reader Service card, p 123

Economical in operation...
Dependable always

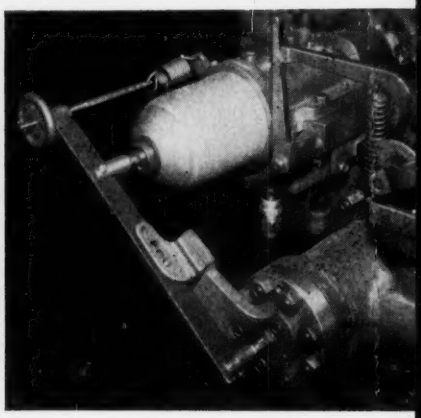
ELLIOTT



Precise alignment of shaft, through true centerline support, permits smooth and dependable operation at all operating temperatures. The entire rotor assembly is dynamically balanced.



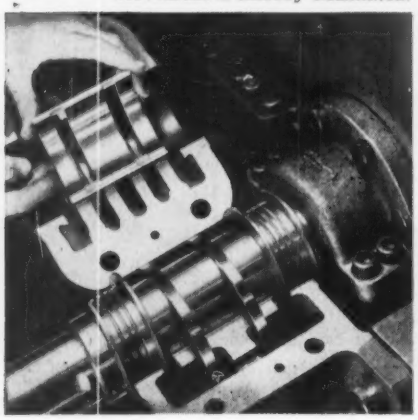
Accessible shaft-seals simplify maintenance and routine inspection. Shaft surface under packing glands is stainless steel. Covers are readily removable without disturbing the upper-half casing.



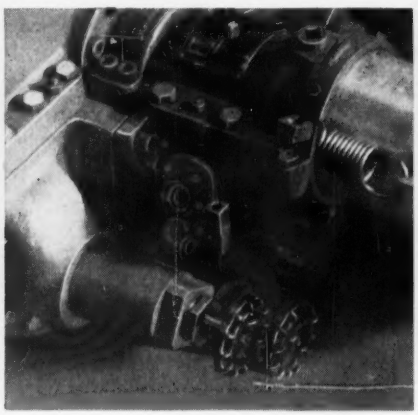
Simple, Positive direct-acting speed-governing system is dependable, weather-proof, accurate. Separate trip gives positive overspeed protection, and it may be easily reset against line pressure.

Only ELLIOTT Turbines give you all these PLUS features

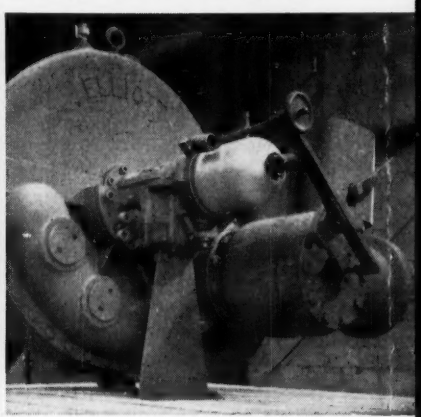
By separating the pedestal-mounted exhaust-end bearing from the hot turbine casing, the temperature distortion is minimized, and the vertical shaft movement is thereby eliminated.



Steam-saving hand valve with pilot, which can be opened against full steam pressure, reduces steam consumption at partial loads. This feature is available on all sizes of Elliott YR steam turbines.

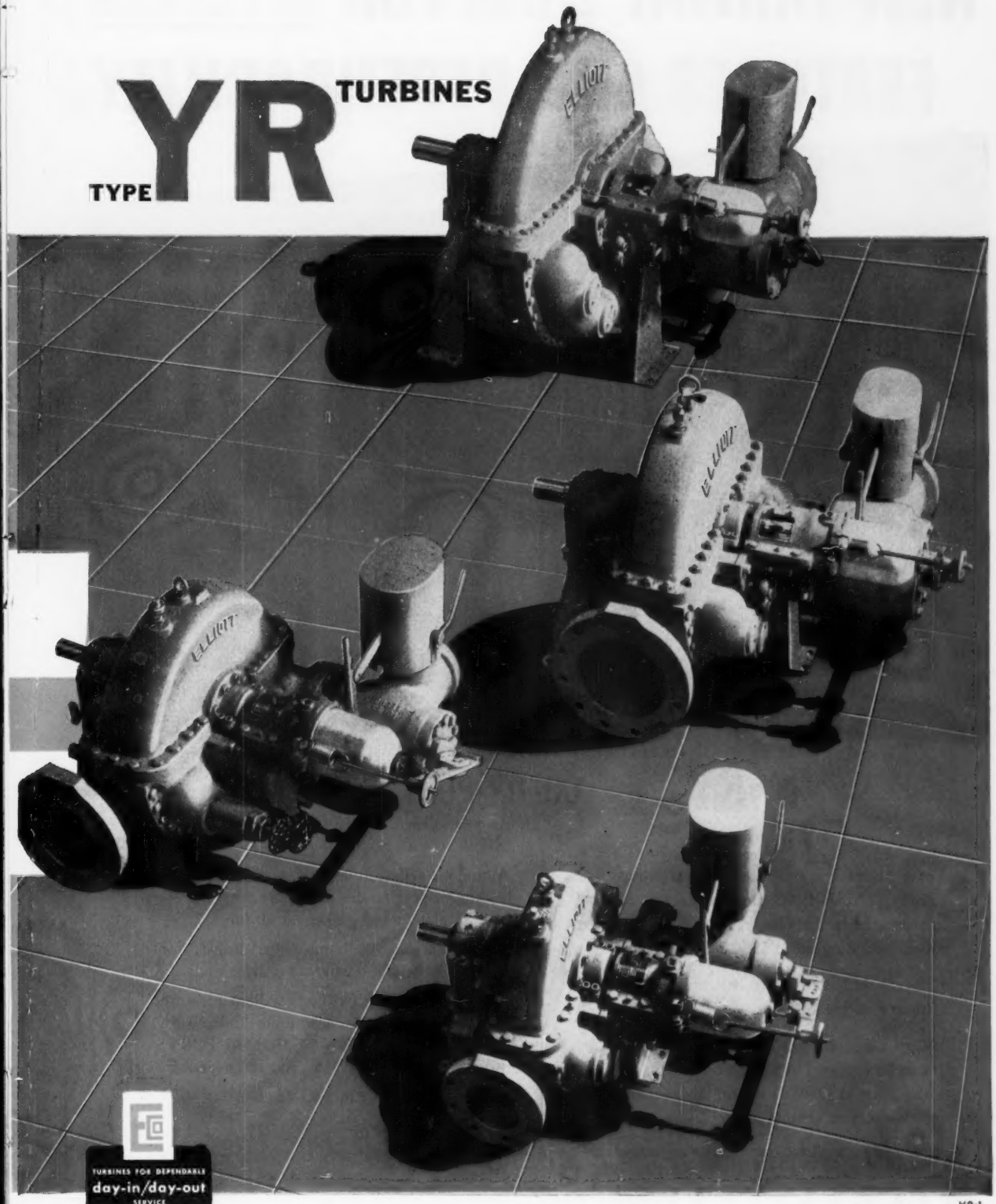


All-weather protection is standard for Elliott YR turbines. They shrug off heat, dirt, snow, moisture or contaminated atmosphere. Stainless steel exposed parts are furnished for extreme conditions.



In addition to the units illustrated here, Elliott makes single-stage turbines in special frames, reduction gears, multistage mechanical drive turbines to 50,000 hp, and turbine-generators ranging through 44 mw.

TYPE YR TURBINES

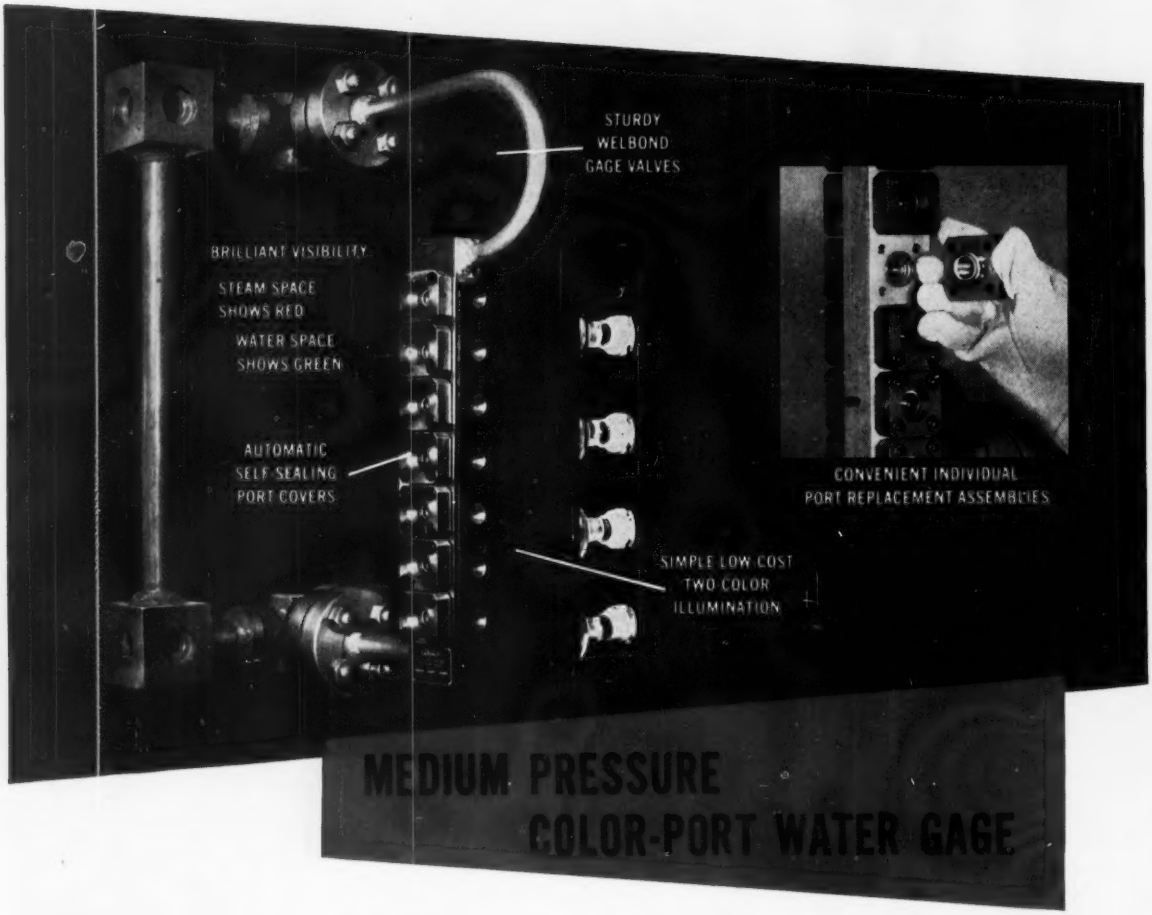


TURBINES FOR DEPENDABLE
day-in/day-out
SERVICE

HB-1

ELLIOTT Company JEANNETTE, PENNA.

NEW YARWAY TRIM FOR MEDIUM FEATURES AND DEPENDABILITY


STURDY WELBOND GAGE VALVES
BRILLIANT VISIBILITY
STEAM SPACE SHOWS RED
WATER SPACE SHOWS GREEN
AUTOMATIC SELF-SEALING PORT COVERS
SIMPLE LOW-COST TWO-COLOR ILLUMINATION
CONVENIENT INDIVIDUAL PORT REPLACEMENT ASSEMBLIES
MEDIUM PRESSURE COLOR-PORT WATER GAGE

These advantages, so successful in high pressure* Yarway Color-Port Water Level Gages, are now incorporated in the new Yarway Color-Port for boilers operating up to 1050 psi.

- Bright red and green readings. Full gage shows all green; empty gage, all red.
- Low maintenance. Individual port assemblies can be replaced in a matter of minutes—with the gage in place. Efficient illuminator spotlights reduce lighting costs.
- Automatic self-sealing ports. Exclusive spring loading of port covers maintains proper pressure on glasses and gaskets at all times.
- Sturdy Yarway Welbond Gage Valves for positive, dependable shut-off service.

For replacement on existing medium pressure boilers or specifying on new units, make sure your next gages are YARWAY COLOR-PORT. Visibility ranges of 13", 15½" and 18" available.

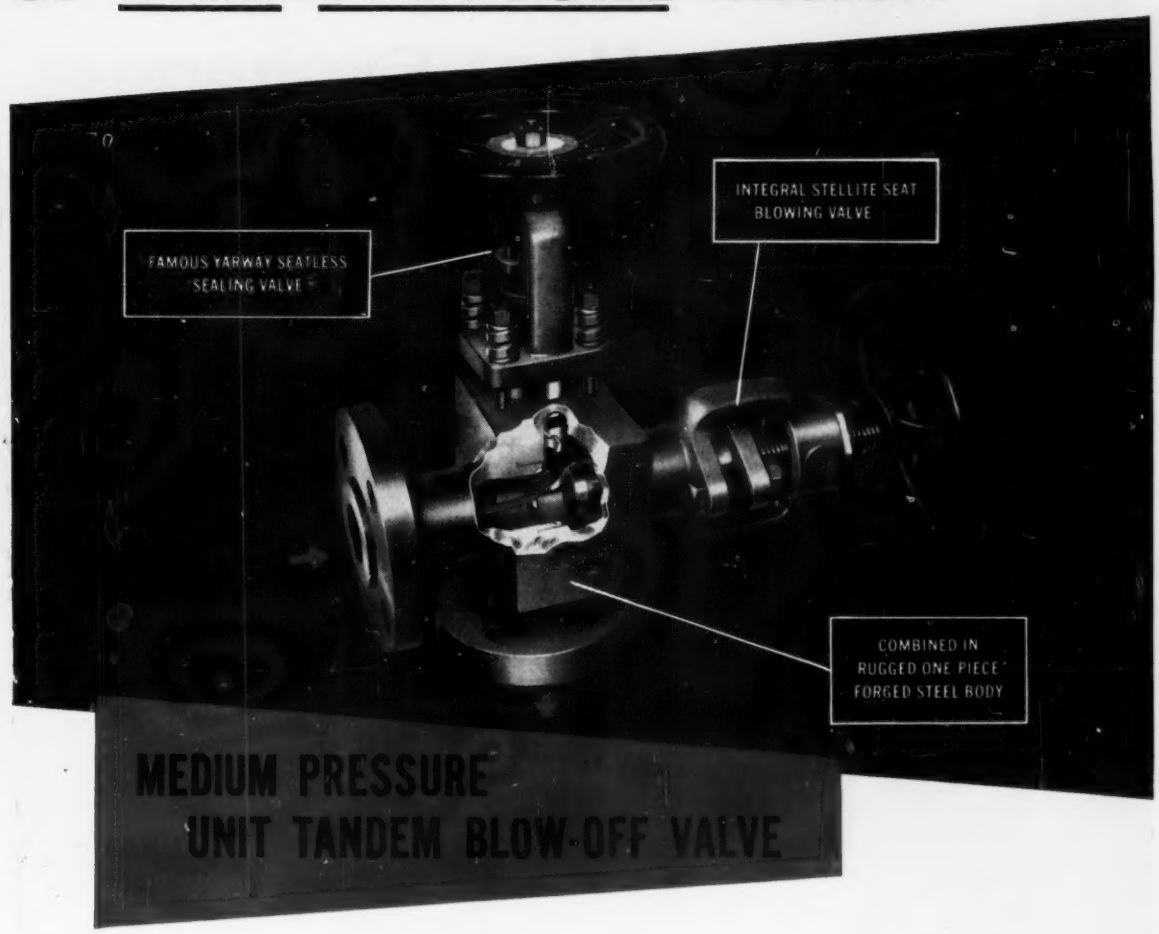
Write for new Bulletin WG-1815.

*up to 3000 psi

YARWAY

A MARK OF QUALITY

PRESSURE BOILERS HAS UNIQUE OF HIGH PRESSURE DESIGN


FAMOUS YARWAY SEATLESS SEALING VALVE
INTEGRAL STELLITE SEAT BLOWING VALVE
COMBINED IN RUGGED ONE PIECE FORGED STEEL BODY
MEDIUM PRESSURE UNIT TANDEM BLOW-OFF VALVE

The established success of the high pressure Yarway Unit Tandem Valve is directly responsible for this new medium pressure Yarway Valve. It brings premium quality Yarway dependability to medium pressure boilers (up to 665 psi)—*at a competitive price.*

Important Yarway features like nitralloy plunger in the sealing valve, integral stellite seat and disc in the blowing valve, streamlined design, rugged forged steel body—make this your best blow-off valve buy.

Install this new Yarway Medium Pressure Unit Tandem and you'll know why *over 80% of all high pressure plants are Yarway Blow-off Valves.*

Write for Bulletin B-435, Supplement A.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

IN STEAM ENGINEERING

For more facts circle 211 on Reader Service card, p 123

How lasting quality is Heat Exchanger

5 ENGINEERING RESEARCH

(FIFTH OF A FIVE-PART SERIES)

Engineering research at new Phelps Dodge mill in South Brunswick, N. J., includes many types of laboratory tests aimed at improving quality control, providing longer tube life.

built into Phelps Dodge and Condenser Tubes...

Recent technical advances pioneered in Phelps Dodge laboratories include tube to tube sheet welding.

More than 40 years of continuing engineering research and manufacturing experience lie behind the lasting quality and long service life of Phelps Dodge heat exchanger and condenser tubes. This vast background has constantly made new contributions to the industry. Phelps Dodge pioneered the manufacture of long length tubes, Dual-gauge tubes and bell-end tubes, keeping pace with the changing designs of heat transfer equipment. Phelps Dodge also has an established reputation as a specialist in the manufacture of duplex tubes, fluted tubes and U-bend tubes.

The Phelps Dodge research staff of chemists, engineers and metallurgists combine their skills on all kinds of tube problems. By analyzing and evaluating the key factors—water pollution, acidity, corrosion, temperature variation effects and other conditions that vitally affect tube performance—they suggest the alloy best suited for particular operating conditions.

This valuable "know-how" goes beyond laboratory analysis and alloy specifications. It is applied to increasing tube service life through ever closer control of quality and to improvement of fabricating and testing equipment. Special non-destructive tests, including eddy current, dye penetrant and ultrasonic inspections, are examples of the latest testing developments used by Phelps Dodge.

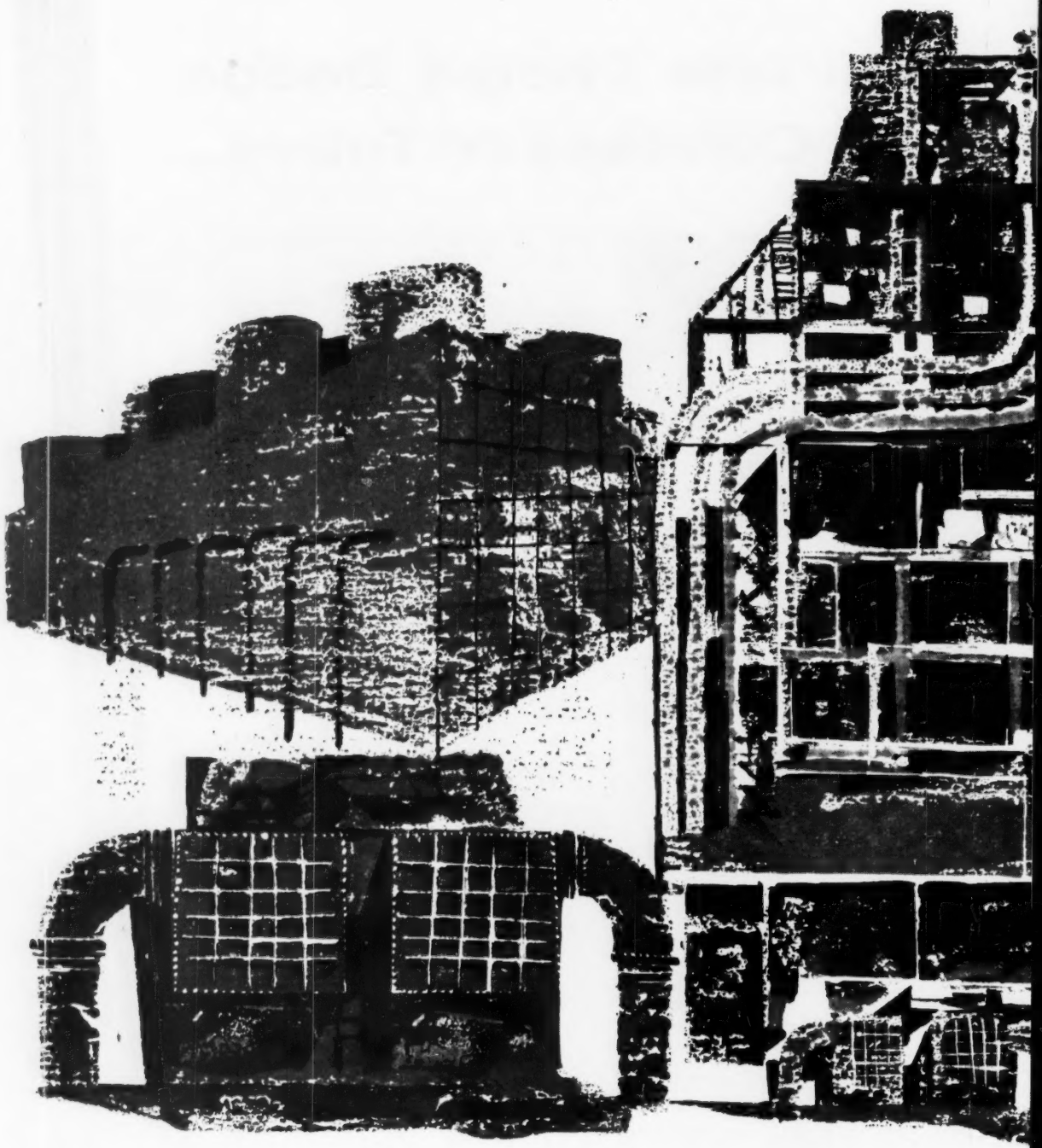
Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

PHELPS DODGE COPPER PRODUCTS CORPORATION

First for Lasting Quality—from Mine to Market!

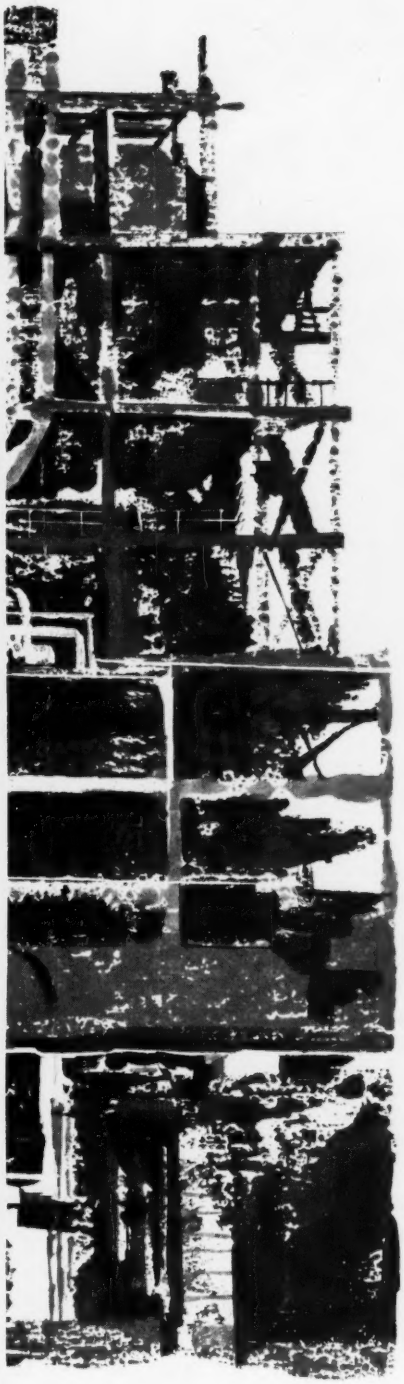
SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Denver, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

For more facts circle 212 on Reader Service card, p 123



POWER PLANT PRODUCTS HEAT ENGINEERED BY FOSTER WHEELER:

Central Station and Industrial Steam Generators • Steam Condensers and Pumps • Pulverized Fuel Systems • Feedwater Heaters • Packaged Steam Generators • Cooling Towers • Nuclear Components



The one kind of engineering every plant needs

You may use heat to produce steam, electricity, or chemical reactions—but if you use it for any industrial purpose at all, heat is probably one of your major items of operating expense. There's also a good chance that heat is costing you more than it should.

That's because every piece of equipment that uses heat—be it a steam generator, heat exchanger, or simply piping—is a potential weak spot in your budget unless it is engineered to get the *optimum* out of the heat-dollars you put into it. At Foster Wheeler, getting the *most* out of heat is expressed as *Heat Engineering.*

Heat Engineering is the reason you'll see FW-built equipment in such critical places as nuclear power stations, on the world's largest and most efficient tankers and naval ships, in giant steam-electric plants, and refineries and chemical process plants of all types and sizes.

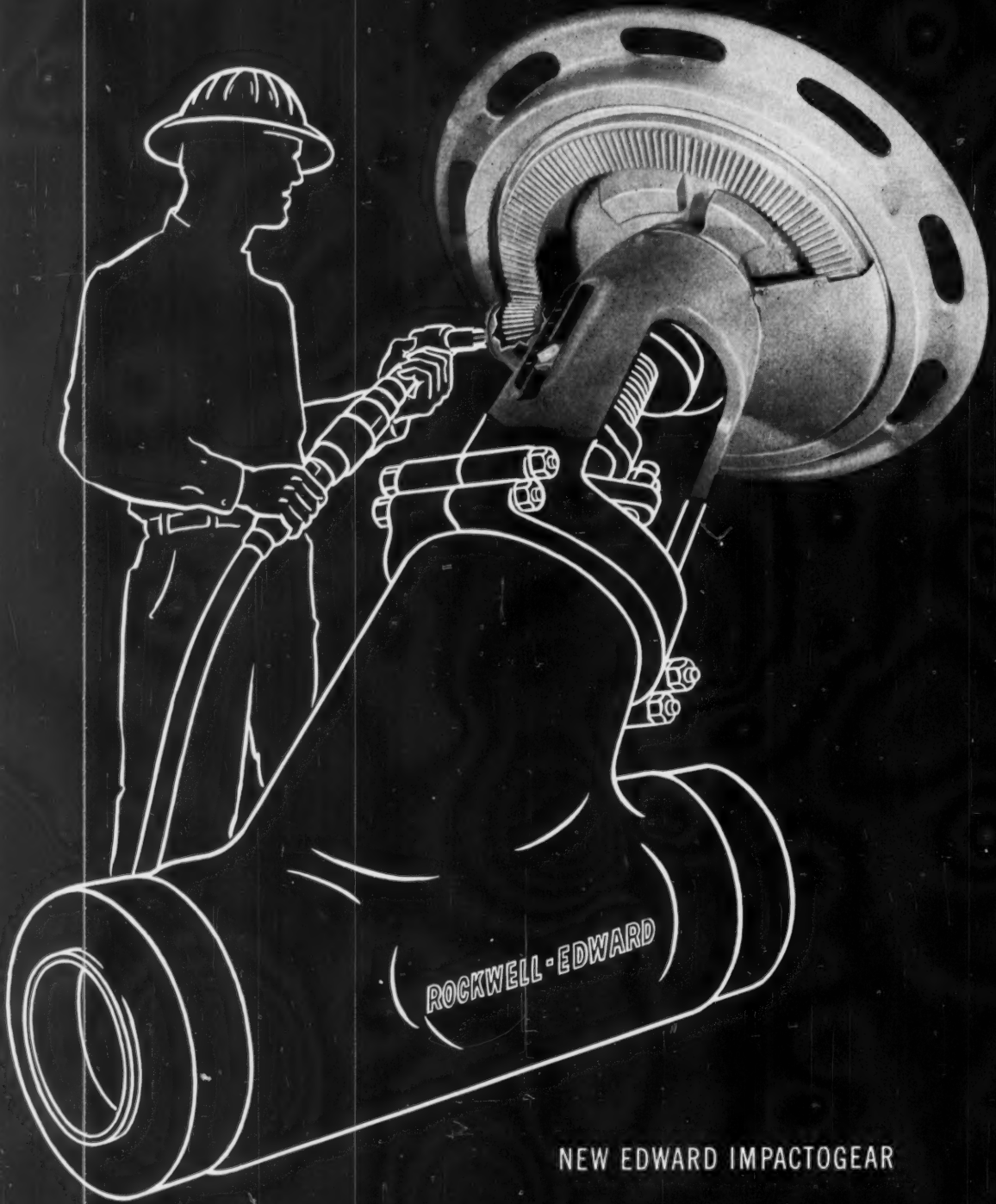
If your company is contemplating *any* modernization, expansion, or replacement where heat is concerned, why not check into the difference *Heat Engineering* can make? Contact Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N. Y.

Heat Engineered products, plants and processes . . . for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

For more facts circle 213 on Reader Service card, p 123



NEW EDWARD IMPACTOGEAR

What's New from Edward Valves

New Products . . . Solutions to Problems . . . Information on Steel Valves from Edward, Long-Time Pioneer in the Field!

How Impactogear* operates high-pressure valves

You no longer need a crew of men to open or close big, high-pressure valves. New Edward Rockwell-built Impactogear makes big-valve operation a quick and easy job.

FAST AND EASY "RUNDOWN"

Your operator simply applies portable air or electric wrench to pinion shaft-end of Impactogear. When power is applied, pinion turns ring gear, which turns handwheel and moves the stem to "closed" position. Impactor* handwheel then gives final tight shut-off with unique "hammer-blow" action. (Tests show it delivers 12 times the closing force of ordinary handwheels—with less effort!) Impactogear works quickly, can operate a 2500-lb 10" valve (for example) in only 2½ minutes. And Impactogear can be fitted to any 8" or larger Edward valve of 900-lb (or higher) pressure class.

IMPACTOGEAR WITH AIR WRENCH

Impactogear utilizes standard portable air or electric wrenches generally available throughout industry. Example below shows how two typical air wrench ratings can be applied:

Wrench Type No. 1—Stall torque 170 ft-lbs: Free speed 225 rpm; Weight 12 lbs

For 12" and 14" 2500 lb. valves, operating pressures to 3500 psi

For 10" 2500 lb valves, all allowable operating pressures

For 10", 12" and 14" 1500 lb valves, all allowable operating pressures

For 12" and 14" 900 lb valves, all allowable operating pressures

Wrench Type No. 2—Stall torque 200 ft-lbs: Free speed 300 rpm; Weight 38 lbs

For 12" and 14" 2500 lb valves, operating pressures 3500 psi to 4500 psi

IMPACTOGEAR WITH ELECTRIC WRENCH

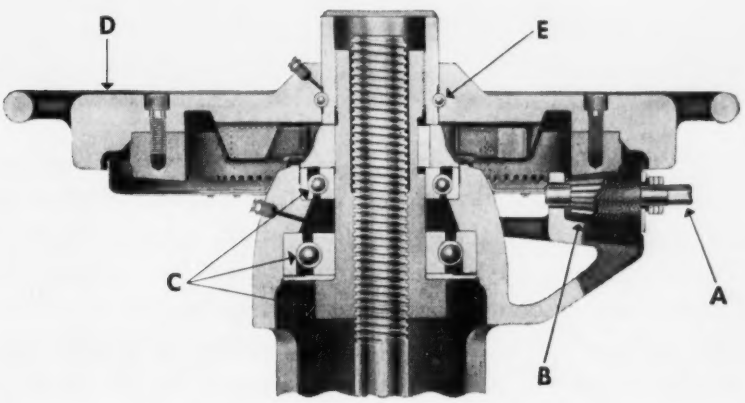
Portable electric wrenches are equally practical. Example below shows a typical electric wrench rating as applied to Impactogear:

Wrench Type No. 1—Stall torque 176 ft-lbs: Free speed 225 rpm; Weight 44 lbs

For 10" 2500 lb valves, all allowable operating pressures

For 10" and 12" 1500 lb valves, all allowable operating pressures

For 12" and 14" 900 lb valves, all allowable operating pressures

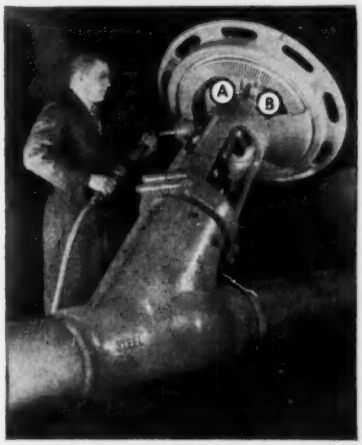


Details of new Impactogear and Impactor Handwheel:

A—Hex head of pinion gear shaft. Power wrench is applied here. B—12-to-1 bevel gear ratio is typical for median size handwheel. C—Exclusive EValthrust yoke bushing combines radial and thrust bearings for easy operation and long life. D—New Impactor handwheel concentrates mass near outer circumference for maximum impacting efficiency. E—New extra bearing increases operating efficiency.

SLASH COST OF VALVE OPERATION

Individually installed operating motors are a big investment. They can add as much as 100% to the basic valve cost. *But now you can save that money by standardizing on Impactogear*—radically simple, thoroughly dependable mechanism utilizing *existing* compressed air or electric facilities. Your Edward Representative will be glad to provide full details and help you determine how Impactogear can work to your best advantage. Contact him—or write *Edward Valves, Inc., 1230 W. 145th Street, East Chicago, Indiana.* (Subsidiary of Rockwell Manufacturing Company). Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W., Montreal 1, Quebec.



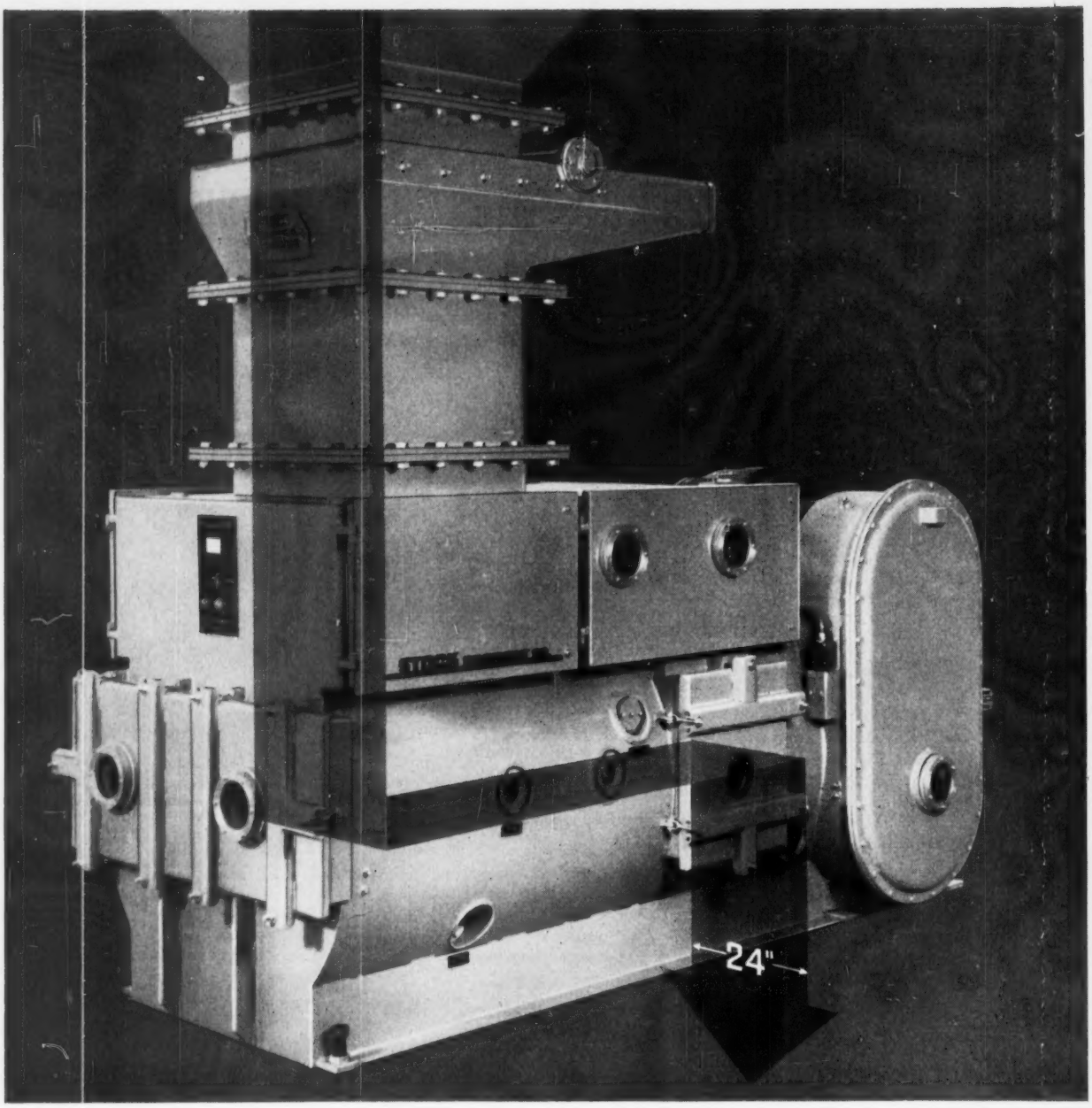
LIGHTWEIGHT PORTABLE WRENCH can operate as many Impactogear-equipped valves as desired. Or, each valve can be fitted with its own wrench. Either way, you get lower operating costs. Final closing is effected by handwheel lugs (A) striking hammer blows against cross arm keyed to yoke bushing (B). Half of gear cover was removed for illustration purposes.

*T.M. Reg. U.S. Pat. Off.

EDWARD STEEL VALVES
another fine product by
ROCKWELL

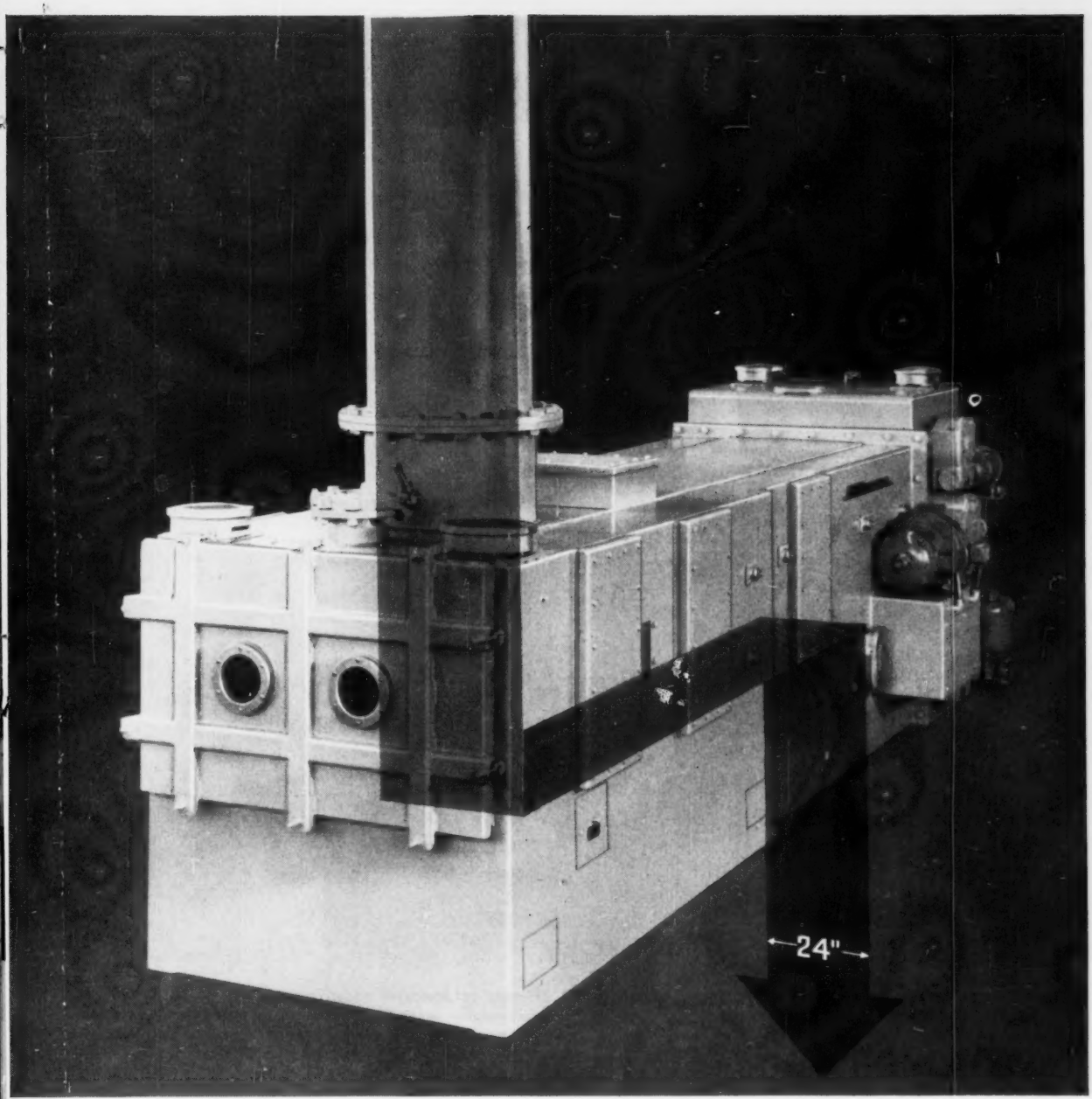
Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18", in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressures up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.

For more facts circle 214 on Reader Service card, p 123



S-E-Co. Volumetric Feeders and S-E-Co. Gravimetric Feeders assure maximum reliability of coal feed to pulverizers and to cyclone burners because they carry the coal 24" wide on the feed belt. The 24" clear width provides ample space for the passage of oversize pieces of coal or occasional foreign objects. Not only does this contribute to reliability of feed, but it minimizes fluctuations in the volumetric efficiency and correspondingly leads to

24" WIDTH OF COAL ON BELT



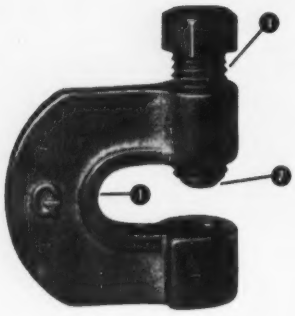
a more uniform discharge. Carrying the coal in a 24" wide stream on the feed belt also means that wet, sticky coal is handled with the same ease as dry coal. It is the unobstructed 24 inches that provides the best assurance of uninterrupted feeder operation.

STOCK Equipment Company
725 HANNA BLDG. • CLEVELAND 15, OHIO

MEANS GREATEST RELIABILITY

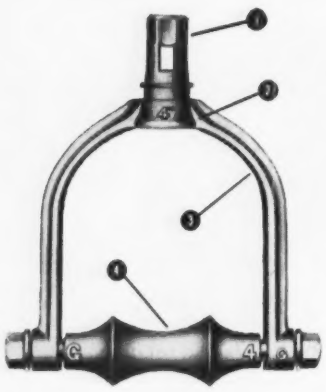
For more facts circle 215 on Reader Service card, p 123

Look at all the extras you get in Grinnell Pipe Hangers . . . yet you pay no more!



GRINNELL C-CLAMP, FIG. 88 — 1 Ribbed, malleable iron casting, for extra strength **2** Hardened steel, cup-point set screw for good "grip" on beam **3** Full thread engagement – casting is drilled and tapped for rod and set screw

GRINNELL EXTENSION SPLIT RING, FIG. 138 — 1 Nipple engaging thick section of malleable iron gives rigidity for support from above, below or from wall **2** Tapped to take screw. No nut to lose **3** Special ring contour holds pipe or tubing firmly



GRINNELL ADJUSTABLE SWIVEL PIPE ROLL, FIG. 174 — 1 Swivel shank permits adjustment without elaborate support **2** Locking device prevents accidental adjustment change; no lock nut required **3** Ribbed design in malleable iron for better strength, lightness, appearance **4** Easy installation; maximum adjustment

GRINNELL CB CONCRETE INSERT, FIG. 282 — 1 One body size accommodates several sizes of rods **2** Slot takes reinforcing rods to assure maximum load rating **3** One-piece body prevents concrete seepage **4** Teeth on insert and nut hold rod firmly in place **5** Homogeneous composition of malleable iron throughout

You get *more* hanger for the money from Grinnell, because Grinnell's huge volume reduces production costs . . . lowers prices right into line with competitive hangers offering less.

Yet you get *so much more* . . . wider choice of types and sizes; better quality control; published ratings for *all* hangers; faster delivery from warehouses nationwide; and more responsible field service by trained Grinnell personnel . . . regardless of how far from the job site the sale was made! Grinnell Company, 277 West Exchange St., Providence 1, R. I. Branch Warehouses in Principal Cities.

Remember, The Best Costs No More — from America's #1 Supplier of Pipe Hangers and Supports

Call your local Grinnell Distributor for pipe hangers, cast and malleable iron fittings, malleable unions, steel nipples – all made by **GRINNELL**

For more facts circle 216 on Reader Service card, p 123

Change hats
with your maintenance man . . .

You'll find out, with . . .

Vertical Lift Metal-clad you perform normal breaker maintenance in 20 minutes

Ask your maintenance man which make of metal-clad switchgear is easiest and quickest to maintain, and it's an odds-on bet he'll tell you General Electric Vertical Lift.

He can show you why. For example, one man, in just 35 seconds, can remove the box barrier to inspect the contacts. The arc chutes do not have to be removed. In fact, he can complete routine maintenance of an entire Vertical Lift breaker in 20 minutes or less. Saving his time saves you dollars. General Electric Company, Schenectady 5, New York. 311-34

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more facts circle 217 on Reader Service card, p 123

predictable, dependable performance...

Republic ELECTRUNITE Boiler Tubing offers Quality you can measure

Predictable, dependable Republic ELECTRUNITE® Boiler Tubes were used in the installation of a new power plant unit for the production of electricity for the Borough of Lansdale, Pennsylvania.

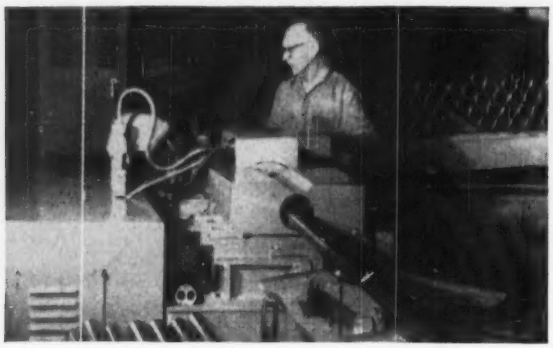
This new steam generator, engineered, manufactured, and erected by Riley Stoker Corporation, Worcester, Massachusetts, is designed to operate at 150,000 pounds of steam per hour, 1000 psi, at a steam temperature of 900° F.

Predictable . . . because ELECTRUNITE Boiler Tubing is hydrostatically or electronically tested to conform with the applicable ASTM specifications and the ASME Boiler and Pressure Code, as well as local, state, and boiler insurance requirements.

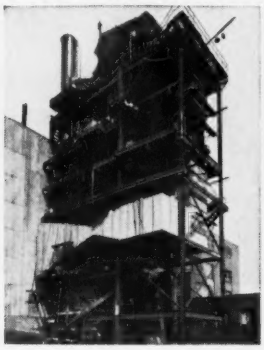
Dependable . . . because ELECTRUNITE Boiler Tubes are made from high-grade steel, produced in Republic's own mills. Operations, materials, and methods are carefully controlled from the time the ore is mined, through mill, and manufacturing processes.

Performance . . . proved on the job, job-after-job. Skilled craftsmen on the job report, "with ELECTRUNITE, the rolling goes well . . . the metal works properly, rolls in smoothly . . . we never worry about cracks in the tubing."

Get the facts. Learn more about Republic ELECTRUNITE for boiler, heat exchanger, condenser, evaporator applications. Call your Republic representative. Or, write direct.



FARROWTEST®—QUALITY YOU CAN MEASURE. Not a laboratory theory, not a mere inspection tool, but an exclusive production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with table below, at no extra cost.



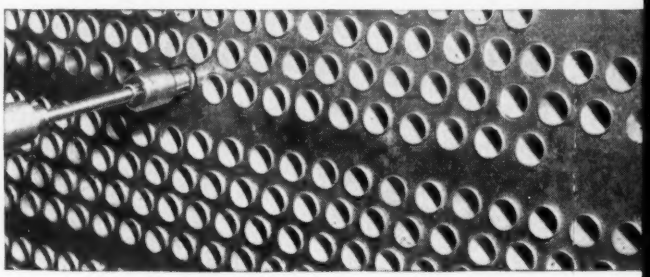
Power plant at Borough of Lansdale does not have a grate surface. Instead, powdered coal fuel which burns in suspension is fed in through water-cooled ports on front wall.

Full normalizing makes Republic ELECTRUNITE uniformly ductile for smooth, easy bending, trouble-free service. This view shows the fuel ports from the inside.

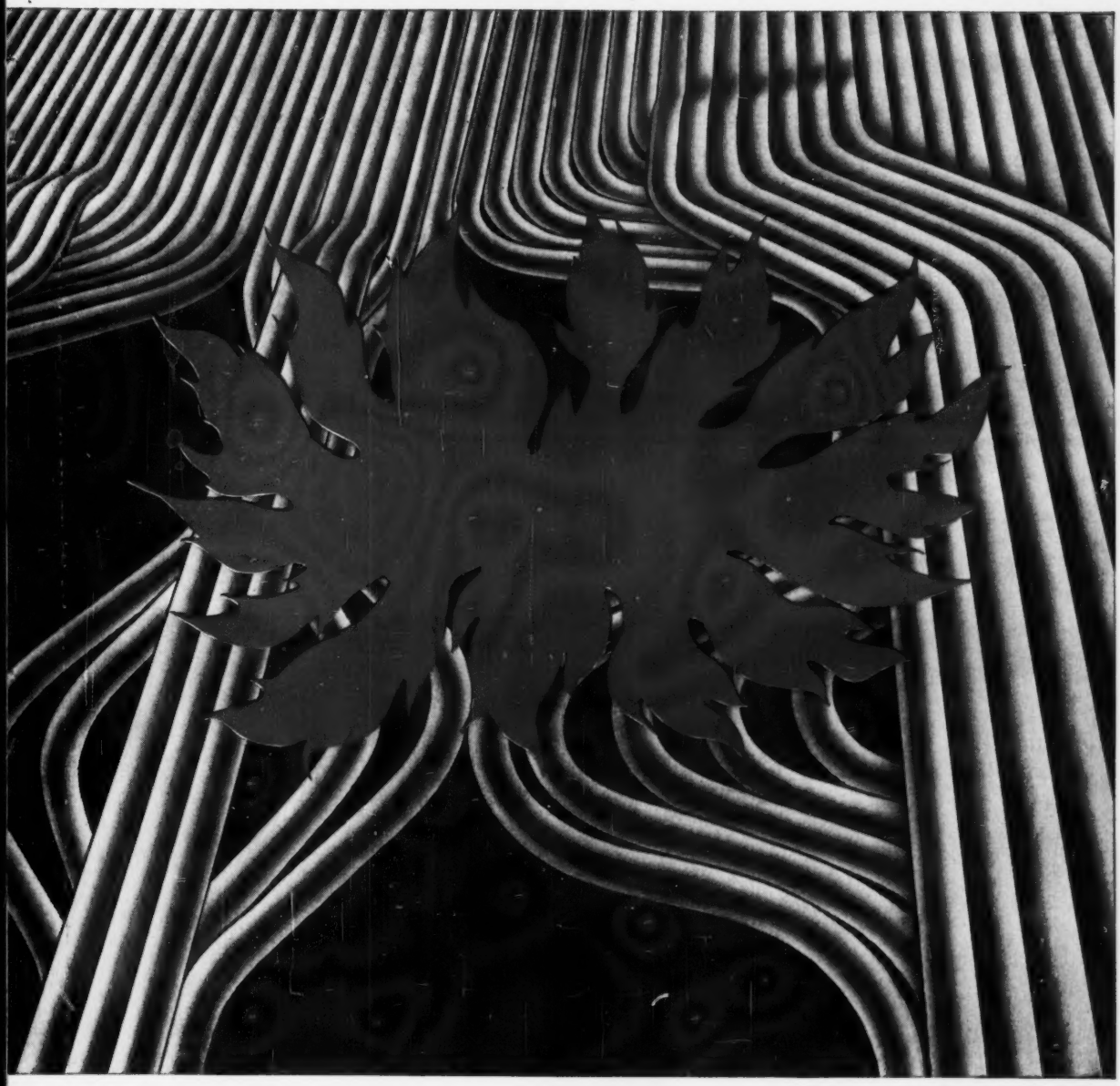
FARROWTEST REJECT TABLE

Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length X Depth Plane)
20	.006″	.0025 sq. inches
18	.006″	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.



More and more engineers in utility companies are considering Republic ELECTRUNITE Stainless Steel Tubing for main surface condensers. Republic's ELECTRUNITE Stainless Steel resists corrosion, provides long, trouble-free service where water is used directly from natural sources. Call your local Republic ELECTRUNITE representative, or write for facts and data.



REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION
DEPT. C-7911-A
221 EAST 131st STREET • CLEVELAND 8, OHIO

Please send more information on the following products:

☐ Republic ELECTRUNITE Boiler Tubes
☐ Republic ELECTRUNITE Heat Exchanger Tubes
☐ Carbon ☐ Stainless ☐ FARROWTEST Brochure

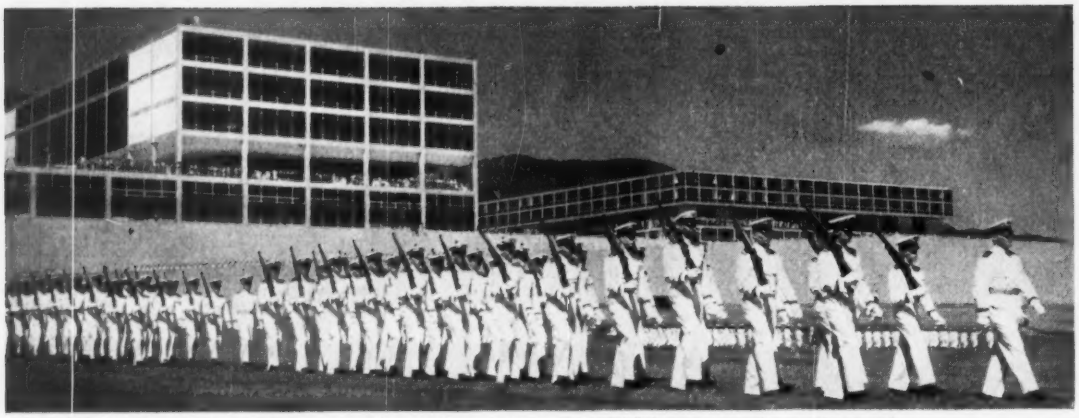
Name_____ Title_____

Firm_____

Address_____

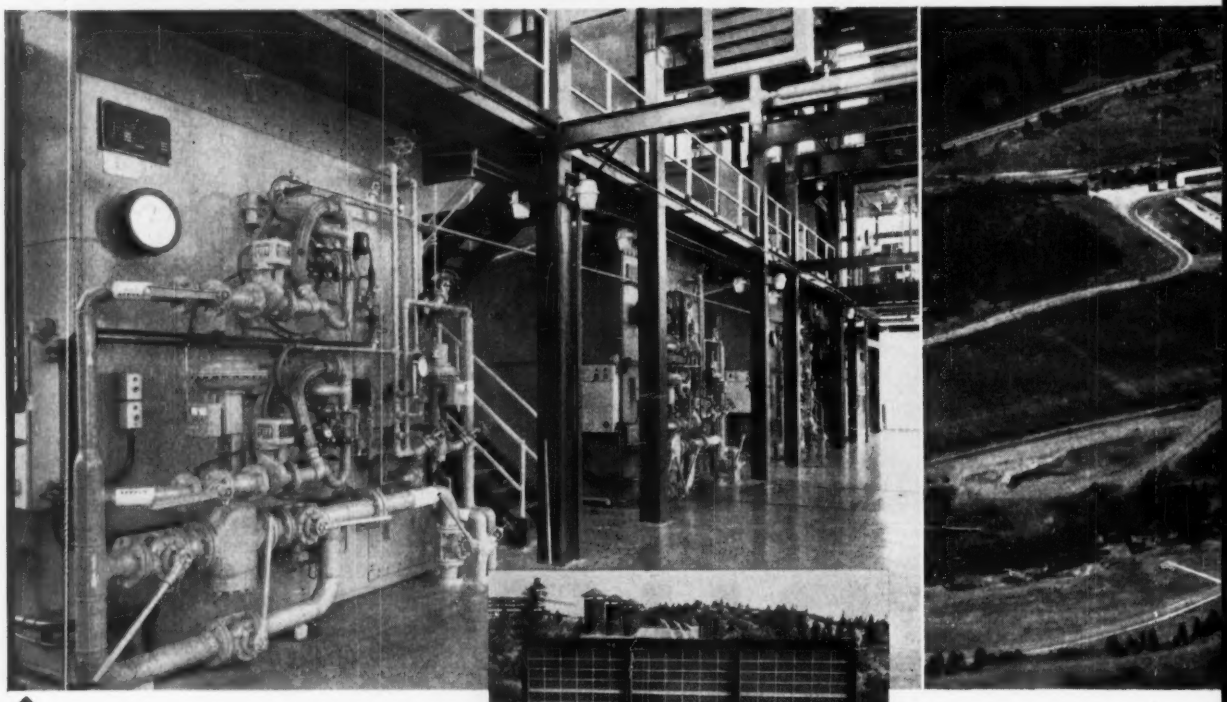
City_____ Zone_____ State_____

For more facts circle 218 on Reader Service card, p 123



Without breaking step, students march down ramp leading from academic and cadet living area onto the parade ground.

HIGH TEMPERATURE WATER HEATS



Compact and efficient, these three C-E LaMont Controlled Circulation Hot Water Boilers serve in the Academy's Academic Area plant. Each has a rated output of 100 million BTUs per hour.

The Academic Area plant, at right, houses the three C-E LaMont Controlled Circulation Hot Water Boilers shown above. The Service Area plant has two smaller C-E LaMont Boilers, each with a rated output of 30 million BTUs per hour.

Catalog HCC-2, describing the C-E Hot Water Boiler, available on request.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS;

Nestled picturesquely in the Rampart Range of the Rockies, seven miles north of Colorado Springs, the new U. S. Air Force Academy is a fitting symbol of the prowess and prestige earned by this branch of our military.

Situated on a sloping site, the Academy grounds are graded, split-level fashion, into a number of broad terraces. Elevations range between 6,400 and 7,000 feet above sea level. The school is divided into two general areas — one for service buildings and one encompassing academic, physical education, dormitory and hospital facilities.

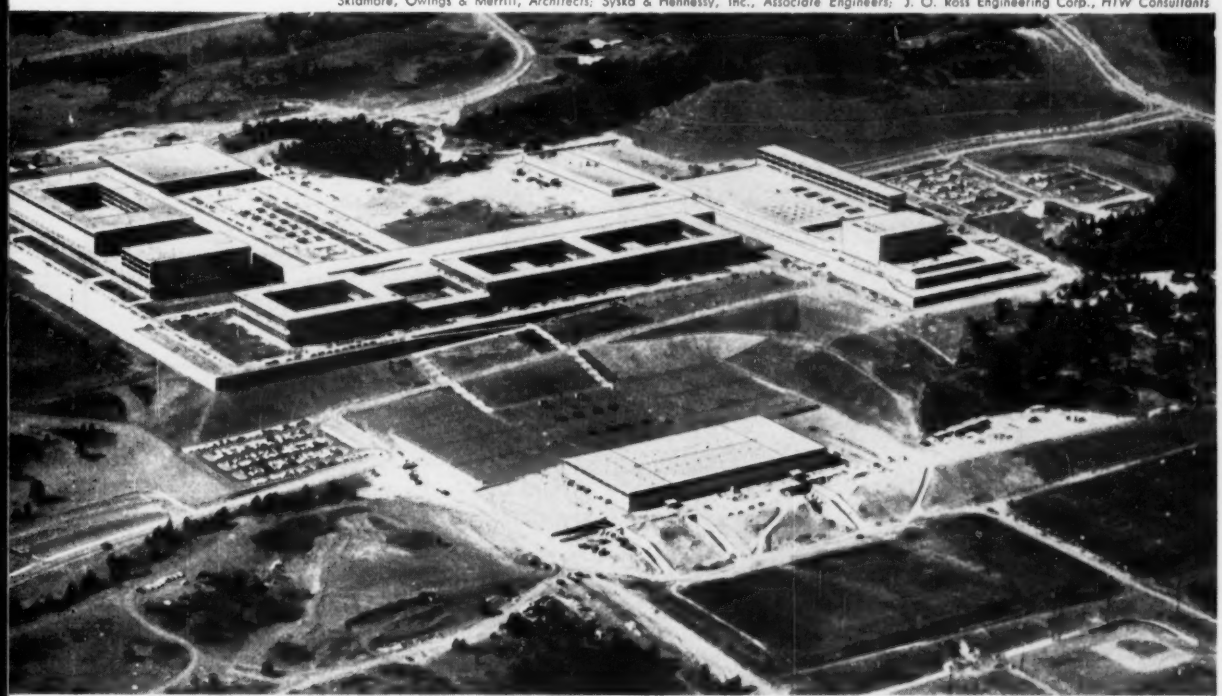
Selecting a heating system to service these widely-spaced buildings and facilities over the rolling and varying terrain required a type that permitted easy and economical pipe line distribution over individual closed circuits exceeding six miles in length—circuits which totally encompass nearly 15 miles.

Because of the irregular terrain and the large area, a steam system would have required a substantial number of steam traps and close attention to piping gradients. High temperature water, on the other hand, offered the advantages of smaller-sized piping with no pressure valves, and a smaller, more compact boiler plant than would have been required for steam ... with 10 to 20 per cent reductions in operating costs.

There are five C-E LaMont Controlled Circulation Hot Water Boilers serving the Air Force Academy. They are located in two separate boiler plants—3 in one and 2 in the other—and have been performing reliably, efficiently and with minimum operating attention since they were first placed in service in late 1957.

THE AIR FORCE ACADEMY

Skidmore, Owings & Merrill, Architects; Syska & Hennessy, Inc., Associate Engineers; J. O. Ross Engineering Corp., HTW Consultants



Nestled against the Rampart Range of the Rockies, the Academy presents an impressive sight from the air. Buildings, from left to right, are: Fairchild Hall, the Academic-Library Building, with Aerodynamics-Thermodynamics Lab and Mitchell Hall (Cadet Dining Hall) behind it; Vandenberg Hall, the Cadet Dormitory; Harmon Hall, the Administration Building; Arnold Hall, the Cadet Social Center; and Planetarium (dome at right). The parade ground stretches at left from sloping ramp. The Physical Education Building and athletic fields are at lower right.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

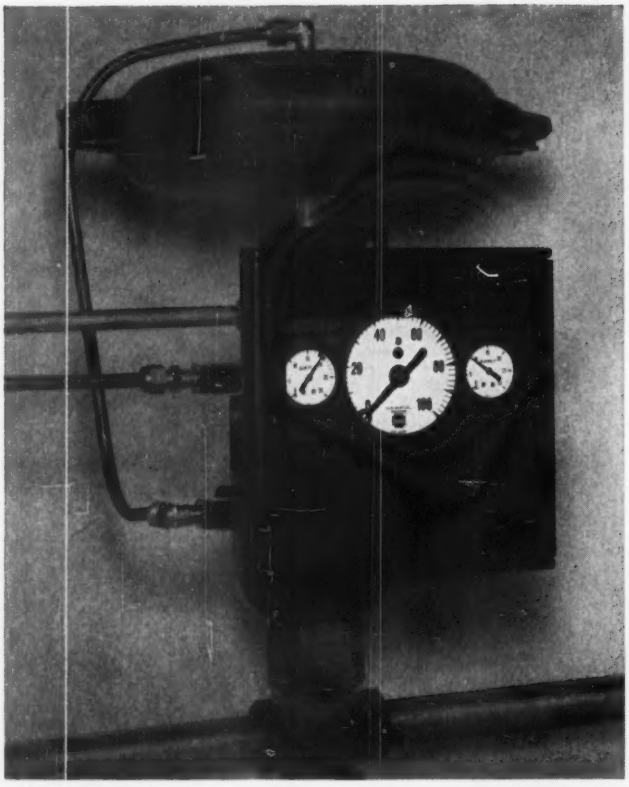
Canada: Combustion Engineering-Superheater Ltd.

C-246

PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

For more facts circle 219 on Reader Service card, p 123

New...from United States Gauge!

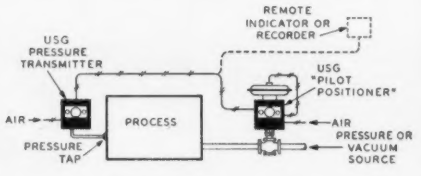


Wide controller model range. The USG Pilot-Positioner is available with most controller models in the USG Pilot line. These include pressure measurement from 30 in. Hg vacuum to 10,000 psi (applicable to liquid level as well), and temperature measurement from —350F to 1000F. Also, proportional band, adjustable for 0 to 75%, or adjustable differential gap (for fast-stroking valve). Unit measures a compact 8½ in. square.

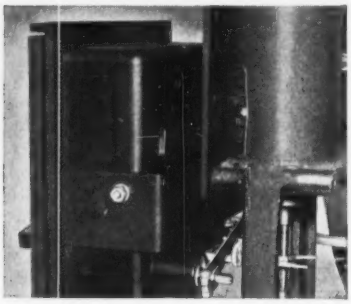
USG CONTROLLER AND VALVE POSITIONER COMBINED!

. . . in low-cost, valve-mounted
U.S. Gauge Pilot-Positioner

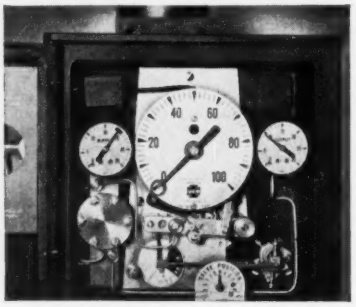
First practical combination of an indicating pneumatic controller and a valve positioner. One compact unit for temperature or pressure control and quick, accurate valve positioning. Check details here. Then send for Bulletin FO29 today!



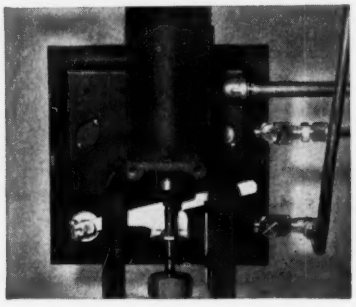
The unit can have its measuring element directly connected to the process. Or, as shown in diagram, it can be a pneumatic receiver for use with all makes of pneumatic transmitters. This permits additional indicating or recording at a remote panel board, as well as indication of the variable at the valve.



Eliminates second unit! Valve-mounted close to the process, the USG Pilot-Positioner minimizes transmission lags, provides higher precision and speed in valve action. Need for separate valve positioner is eliminated, cutting initial cost of two controls and saving on installation and maintenance. Unit fits any standard diaphragm motor valve.



New non-bleed relay. Faster, more accurate and positive positioning action is assured with a new USG-designed, high capacity non-bleed relay. A control by-pass panel with manual-automatic-service positions is offered as an option, mounting underneath the instrument case. Another option permits remote pneumatic set point adjustment.



Mechanical feedback; one air supply. The new Pilot-Positioner employs mechanical feedback through a lever system. Controller's pneumatic components are used to amplify air pressure. Only one air supply required and pressure can be as high as 65 psi. Adjustable for valve stem travels from ⅜ in. to 4 in. Valves can be air-to-open or air-to-close.

Find Your Nearest Distributor In the 'Yellow Pages'

UNITED STATES GAUGE
Division of American Machine & Metals, Inc., Sellersville, Penna.

USG®

For more facts circle 220 on Reader Service card, p 123

circle 221 on Reader Service card, p 123 ➤

COMPRESSOR QUIZ

Take this 5 minute quiz and check your knowledge of balanced opposed compressors.... ANSWERS ON NEXT PAGE. NO PEEKING!

1. What is the reason for an outboard bearing supported motor?

- ☐ Accessibility
- ☐ Shaft alignment
- ☐ Weight saving

2. Which design provides the smallest force couples?

- ☐ Bearing between the crank throws
- ☐ No bearing between the crank throws
- ☐ Both are equal

3. Structurally, what's the critical point in the multi-crank horizontal compressor from a design viewpoint?

- ☐ Lateral forces in the frame
- ☐ Vertical forces in the frame
- ☐ Cylinders

4. What type of motor is usually used on a balanced opposed compressor?

- ☐ Induction
- ☐ Engine-type synchronous
- ☐ Wound rotor

5. Can machine-mounted coolers and interstage piping be factory pre-fitted?

- ☐ Yes
- ☐ No
- ☐ Only on simple arrangements

6. Why is the balanced opposed compressor easier to install than other types of equivalent size?

- ☐ Lighter weight
- ☐ Less parts
- ☐ Semi-packaged design

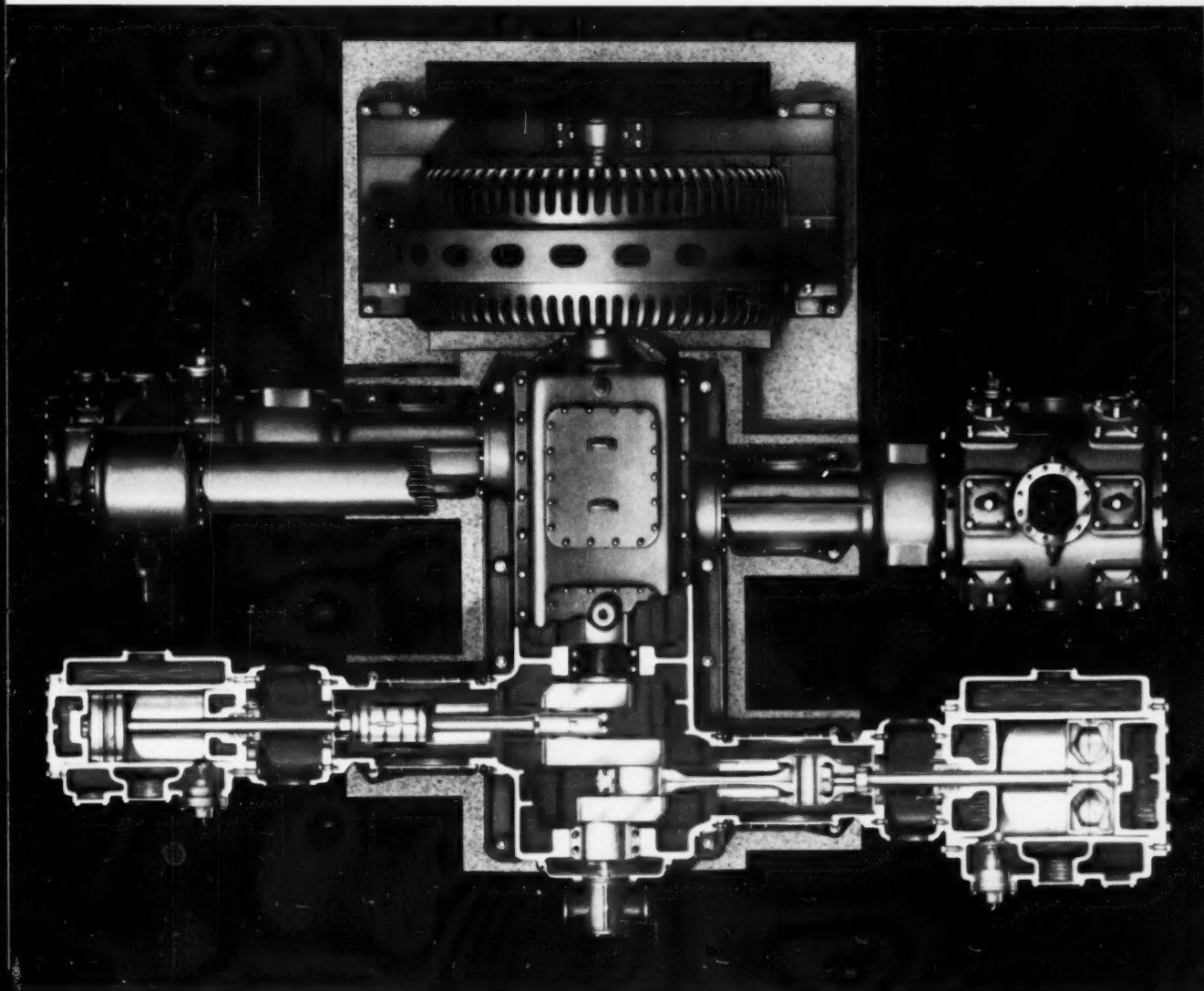
7. Is it common practice to install more than one compressor service on a single multi-cylinder frame?

- ☐ Yes
- ☐ No

8. Industry's most preferred compressor valve is standard with Worthington. It is:

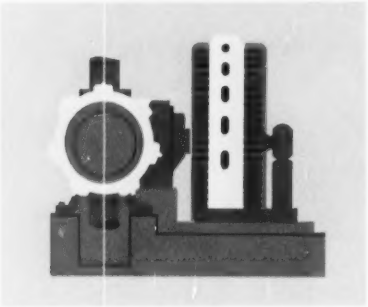
- ☐ A plate valve
- ☐ A spring activated valve
- ☐ A Feather Valve

WORTHINGTON



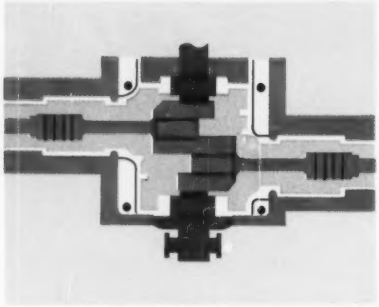
ANSWERS

to key compressor questions on previous page



1. What is the reason for an outboard bearing supported motor?

Ans: Shaft alignment. Secure and permanent support of the large synchronous motor rotor is best obtained by placing a bearing on each side of the rotor.

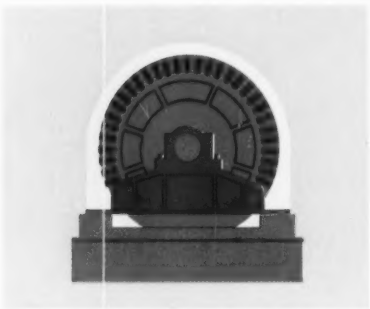


2. Which design provides the smallest force couples?

Ans: No bearing between the throws. Worthington's adjacent crank design reduces couple arm to a minimum.

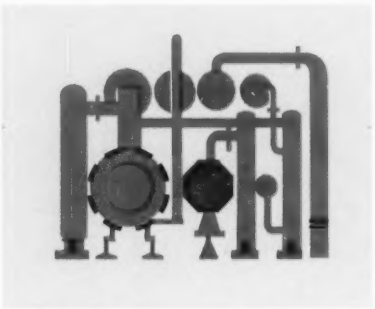
3. Structurally, what's the critical point in the multi-crank horizontal compressor from a design viewpoint?

Ans: Lateral forces in the frame which tend to distort the frame. Worthington's precision machined and fitted tie bars give solid support to the frame, preventing misalignment due to distortion.



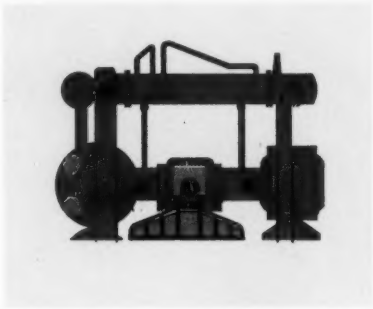
4. What type of motor is usually used on a balanced opposed compressor?

Ans: Engine-type synchronous is the major application; but complete flexibility of Worthington design permits use of any type driver, including turbine and gear or power engine.



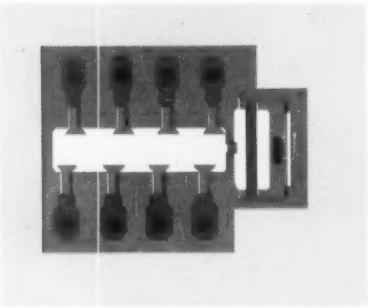
5. Can machine mounted coolers and interstage piping be factory pre-fitted?

Ans: Yes. In fact, when overhead mounted piping and coolers are furnished by Worthington, such piping and coolers are always completely assembled and fitted to the compressor before it leaves the factory.



6. Why is the balanced opposed compressor easier to install than other types of equivalent size?

Ans: Semi-packaged design. Self aligning features permit easy and sure crankshaft, frame, and motor alignment on simplified foundation. Pre-fitted coolers and piping eliminate many problems associated with multi-stage compressor installation.



7. Is it common practice to install more than one compressor service on a single multi-cylinder frame?

Ans: Yes. Particularly where the compression services are related, as in chemical plants. The arrangement results in substantial savings in initial plant cost.

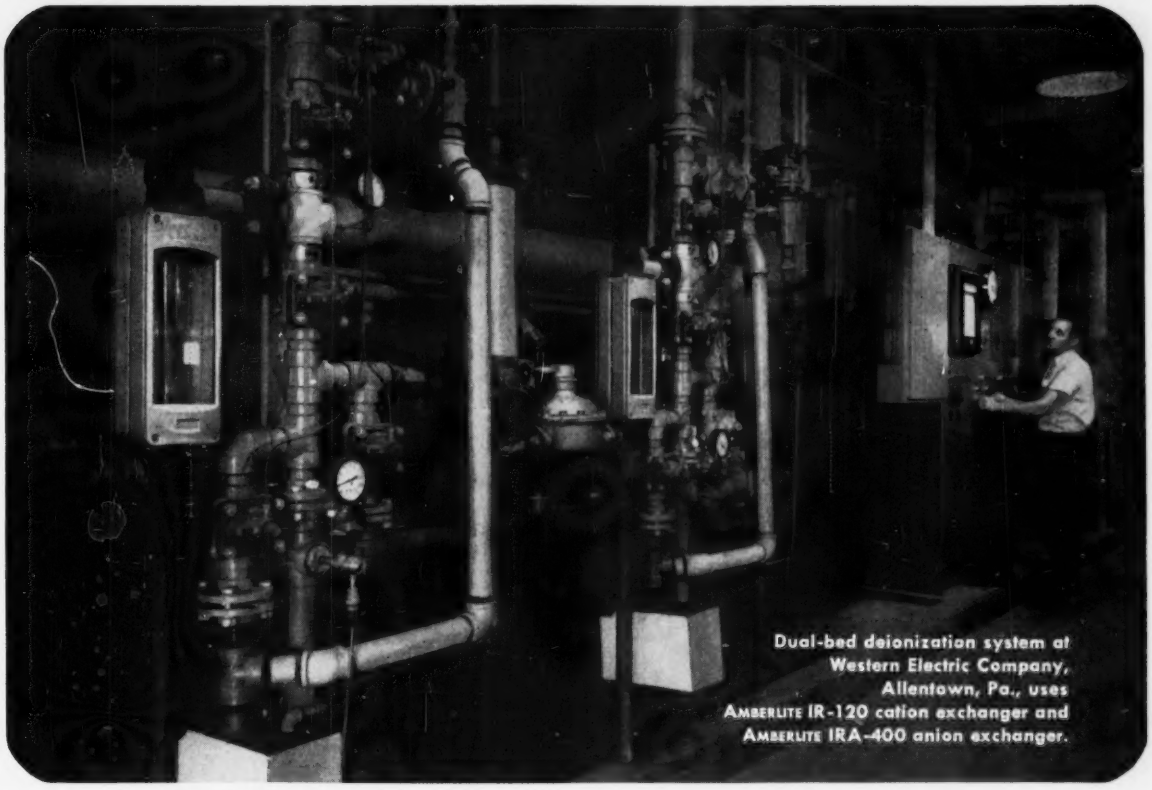
8. Industry's most preferred compressor valve is standard with Worthington. It is:

Ans: Feather Valve! By actual count of 2 to 1, this outstanding compressor valve is preferred by operators and engineers.

SCORING: If you got 7 or 8 questions right you're up-to-date on balanced opposed compressors and you recognize the value of the Worthington machine. If you got 5 or 6 right you're acquainted with some of the benefits of Worthington equipment, but you need brushing up. If you got less than 5 right, get in touch with your nearest Worthington technical representative. He'll give you the full story on the many advantages of the Worthington design. Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) Ltd., Brantford, Ont. 36.5

WORTHINGTON

ION EXCHANGE RESINS aid transistor production



Dual-bed deionization system at Western Electric Company, Allentown, Pa., uses AMBERLITE IR-120 cation exchanger and AMBERLITE IRA-400 anion exchanger.

AMBERLITE-deionized water meets critical specifications at Western Electric Allentown Works

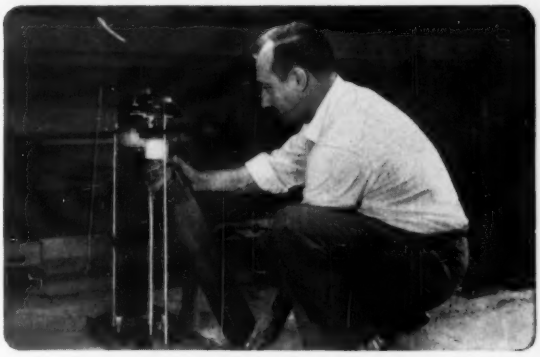
It would take 28 successive distillations in quartz to equal results being delivered by ion exchange at the Allentown, Pa., Works of Western Electric.

Deionized water is used in the preparation of acid and chemical solutions and for washing and cascade rinsing during the manufacture of electron tubes, transistors and semi-conductors. The presence of even minute quantities of metal impurities could seriously affect the performance of these critical electronic parts.

Two grades of deionized water are provided; water from the Allentown City System passes through a bed of AMBERLITE IR-120, cation exchange resin, and then through AMBERLITE IRA-400, anion exchanger, to provide water for most requirements of the plant. Conductivity of the water is reduced in one pass from 250 to 300 micromhos to less than 2.5. This semi-automatic unit has a capacity of 120,000 gallons between regenerations. The treated water is delivered to work stations under a constant head by a recirculating stainless steel grid.

Where water of minimum conductivity is needed, MONOBED units containing a mixture of AMBERLITE IR-120 and IRA-410 are used to polish this deionized water, providing a 40-gallon per hour flow of water with a conductivity of 0.2 micromho or less. These 4-inch diameter cartridge units are removed upon exhaustion for regeneration at a central location in the plant.

Consult your engineering company experienced in water conditioning on how AMBERLITE ion exchange resins may help you. Write for a copy of our booklet "If You Use Water".



MONOBED deionizers containing a mixture of AMBERLITE IR-120 and IRA-410 provide water with a conductivity of less than 0.2 micromho.

AMBERLITE and MONOBED are trademarks Reg. U.S. Pat. Off. and in principal foreign countries.

Chemicals for Industry

ROHM & HAAS COMPANY

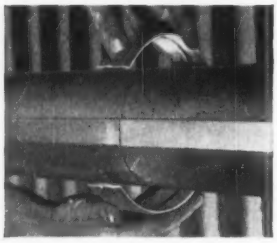
THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

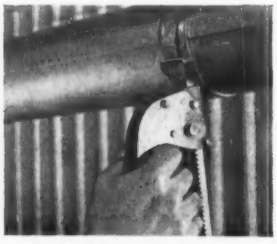
For more facts circle 222 on Reader Service card, p 123

Now! Ready-to-install in a single package
• Thermobestos calcium-silicate insulation
• Gleaming, weatherproof aluminum
• Integral isolation felt

Remove from carton and Metal-On is ready to install. Just snap on pipe and lock in place.



...the specially designed aluminum "snap strap" (containing vapor seal) is snapped on joint...



. . . Metal band completes the assembly . . . provides perfect joint protection against vapor and weather. Available in many colors, the Metal-On band also serves color coding purposes.

Two men completed 660′ Metal-On

New Johns-Manville Metal-On insulation is today's fastest and most efficient way to install high-temperature pipe insulation... and protective metal jacketing

Metal-On is still new! It is just months since its introduction—yet it has already been accepted by virtually every industry in which high-temperature pipe insulation needs protective metal jacketing.

One reason for this rapid, all-out acceptance is Metal-On's installation economy. A single package product that consists of high-temperature insulation and protective aluminum jacket—Metal-On entirely eliminates separate on-the-job metal application. In

Part of 2100-foot Metal-On installation. New plywood plant of the Winton Lumber Co., Jackson, Cal. Insulation Contractor: Western Asbestos Co., San Francisco.

Metal-On pipe insulation presents no fitting problem. It is cut easily right on the job with either power or hacksaws. Available in long, 3-foot sections in a complete range of pipe sizes through 24" . . . by 3" thickness.

this insulation job in one working day!

fact—a section of Metal-On can be applied at least as fast as pipe insulation alone.

However important installation speed may be, it is but one Metal-On advantage! For Metal-On also ends guesswork in specifying aluminum alloys and jacket thicknesses. Its jacket measures an ideal .016" thick . . . of a high-quality aluminum alloy selected expressly for superior weather resistance . . . good appearance . . . and resistance to abuse and pitting.

Of course, Metal-On never needs painting. Won't rust. Is impervious to dirt, oils and grime. And, unlike corrugated metal jacketing, Metal-On has no dirt-collecting grooves—its smooth surface stays clean.

Metal-On also provides top fuel savings and accurate temperature control, because its insulating element is Johns-Manville Thermobestos®, finest of all the calcium silicate insulations for temperatures to 1200F. The conductivity of Thermobestos is lowest of all insulations generally used in power and process industries.

To help you compare Metal-On with the insulation you're now using—let us send you the new technical data brochure, IN-217A. Write for it today. Address Johns-Manville, Box 14, New York 16, N.Y.

JOHNS-MANVILLE JOHNS-MANVILLE JM PRODUCTS

For more facts circle 223 on Reader Service card, p 123

So many ways the ***FISHER/MAN***
can give you a helping hand with the

WIZARD II
PRESSURE CONTROLLERS

- Two Position Controller
- Proportional Controller
- Proportional Controller —Remote Set
- Differential Proportional Controller
- Pressure Transmitter
- Differential Proportional Controller— Remote Set
- Proportional Reset Controller
- Differential Proportional Reset

This "Jack of ALL Trades" is surprisingly low in cost

The partial list of applications at left tells you why the Wizard II is so aptly named. Probably no other controller in the Fisher line is as versatile. Available in brass, steel or stainless steel Bourdon tubes for ranges from 25 to 10,000 psi. Brass or stainless steel bellows available for low pressure service from 30" Hg Vacuum to 30 psi.

Fisher has carefully designed each component of the new Wizard to satisfy the most rigid process control requirements. A completely descriptive and illustrated booklet on the Wizard II is yours for the asking. Write for Bulletin D 4150 A.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Marshalltown, Iowa/ Woodstock, Ontario/ London, England

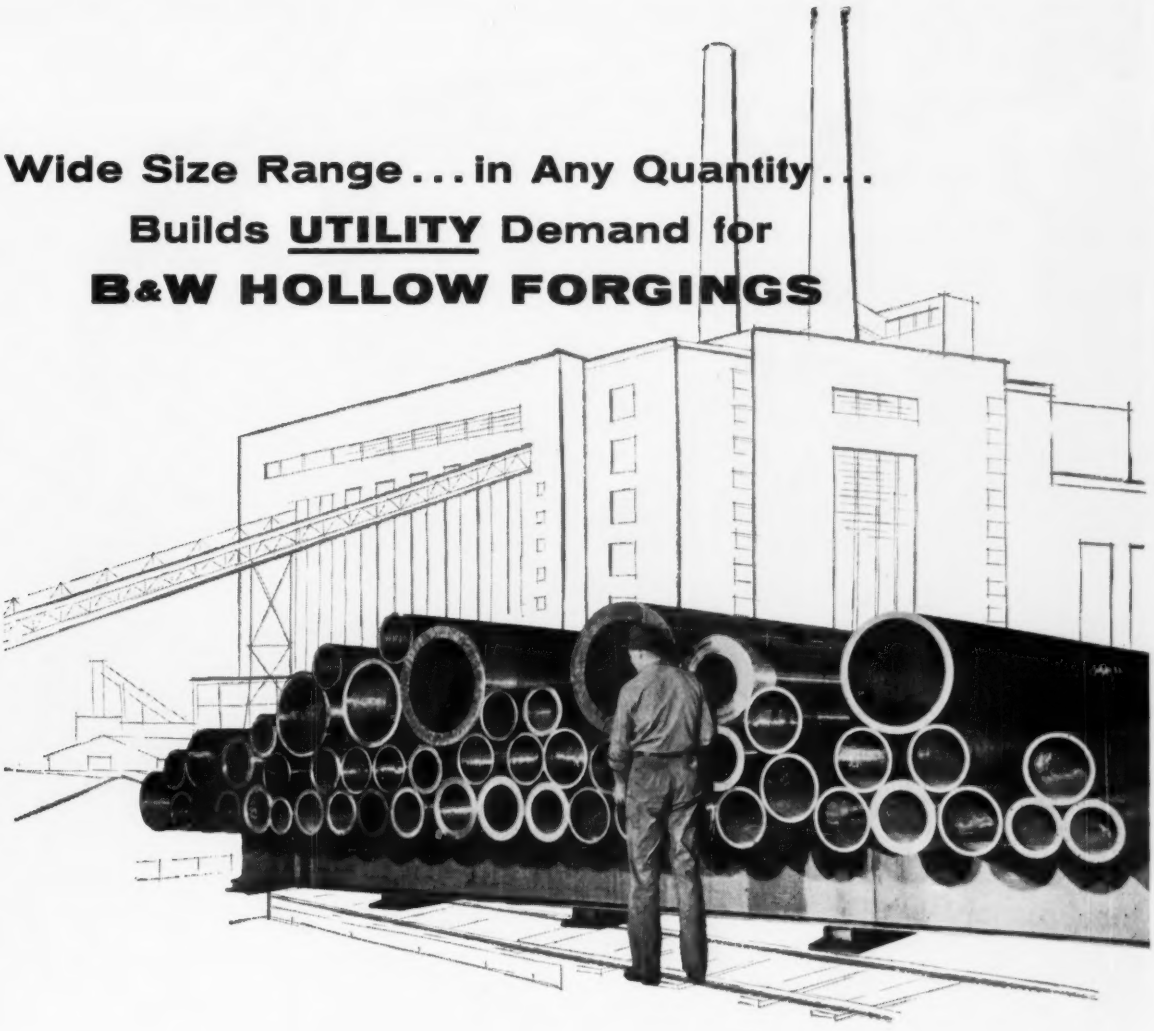
CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

SINCE 1880

For more facts circle 224 on Reader Service card, p 123

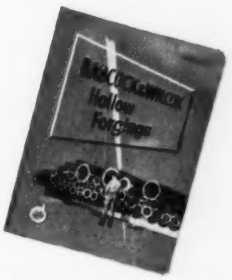
Wide Size Range . . . in Any Quantity . . .
Builds UTILITY Demand for
B&W HOLLOW FORGINGS



Leading electric utilities—like American Gas and Electric, Carolina Power & Light, Commonwealth Edison, and Wisconsin Electric Power—use B&W hollow forgings for main steam, reheater, feedwater, and similar lines. B&W hollow forgings give them a sound solution to their piping problems.

These heavy-duty forgings can be specified to exact design requirements. They are made from high quality carbon, alloy, and stainless steels. They are produced with vigilant care under controlled conditions from the initial melt through final inspection. That's why B&W hollow forgings give users savings in time and money.

For additional information, write for Bulletin S-16. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.



Ask for this Bulletin: S-16

S-473-HF

B&W THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

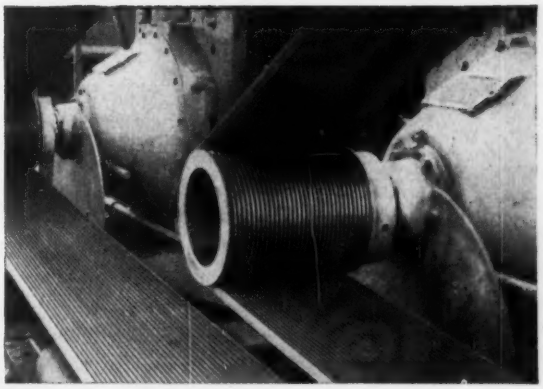
For more facts circle 225 on Reader Service card, p 123

WHY BUY ONLY 2/3 OF A CONVEYOR BELT?

IT'S THE *LAST THIRD* OF R/M CONVEYOR BELT LIFE That Gives "MORE USE *for Your* DOLLAR"

The last one-third of conveyor belt life determines its final cost. And now, R/M's *new* construction concept assures you ⅓ longer life with Ray-Man Conveyor Belt! Every belt feature—troughability, resiliency, fastener holding ability, strength member fabric, cover thickness and toughness—all contribute to your conveyor belt life and cost. Therefore every Ray-Man component is now *precision proportioned* to assure a degree of belt balance never before possible. It adds up to ⅓ longer belt service life... *lower* costs for your coal handling operations.

Let an R/M representative show you how *extra* life in the last ⅓ of conveyor belt service means "More Use per Dollar" with Ray-Man Conveyor Belt and other R/M heavy duty constructions. Write for Conveyor Belt Catalog 25CB.



R/M POLY-V® DRIVE

Patented new drive concept delivers up to 50% more power in same space as conventional multiple V-belt drives . . . or equal power in as little as ¾ the space! Eliminates multiple V-belt "length matching" problems. Poly-V* assures more constant speed ratios, smoother running drive, longer drive life. Single unit belt permits narrower sheaves, less shaft overhang, less drive weight. Write for Bulletin #6638.

**Poly-V is a registered Raybestos-Manhattan trademark.*

CONDOR V-BELTS

"The smoothest running V-belts made" for general service. Balanced construction and straight sidewall design assure *more* grip, *less* slip . . . *longer* trouble-free performance at *lower* cost. For shock loads under rugged drive conditions, R/M Super-Power V-Belts give up to 40% greater hp capacity compared to standard types. Write for Bulletins.

RAY-MAN CONVEYOR BELT

Trains Naturally

Holds Fasteners

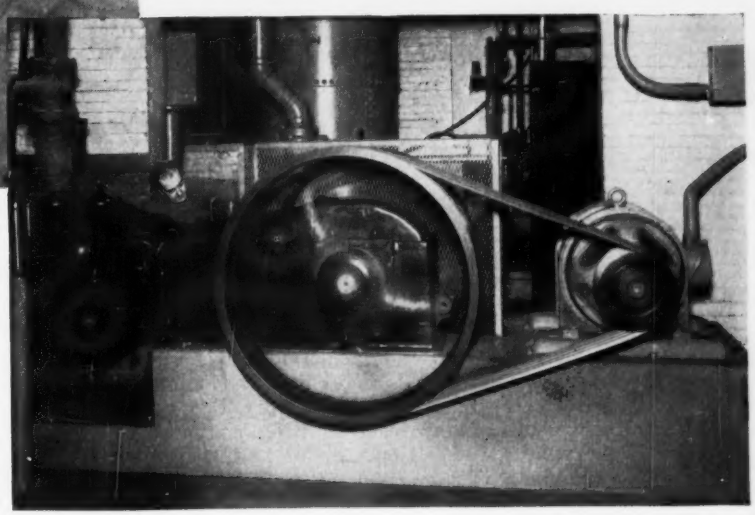
Resists Impact and Ripping

Requires No Breaker Ply

Double Compensation Relieves Outer-Ply Stress

Exclusive "XDC" Long-Wear Cover

Moisture Resistant, Mildew-Proof



RM-857

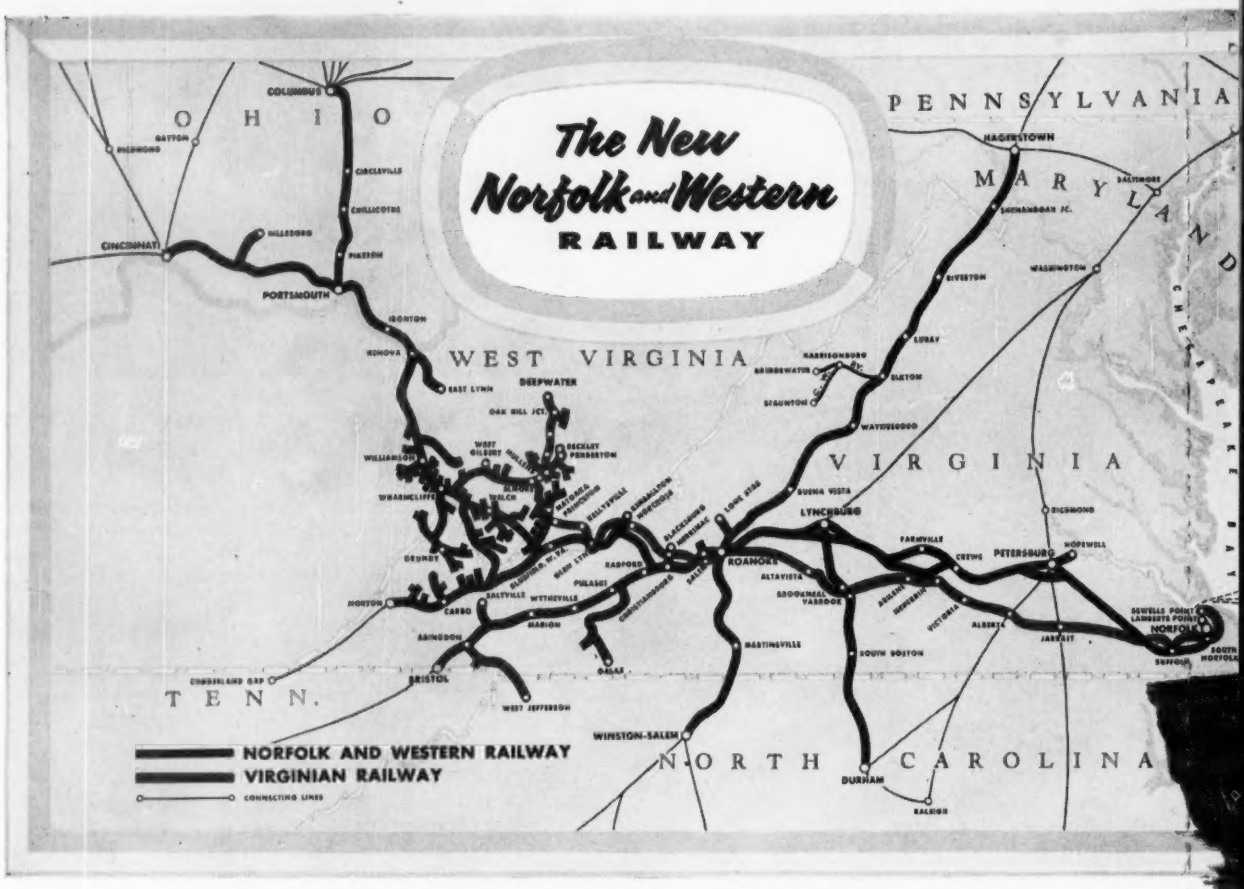
BELTS • HOSE • ROLL COVERINGS • TANK LININGS • INDUSTRIAL RUBBER SPECIALTIES

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products: Abrasive and Diamond Wheels • Brake Blocks and Linings • Clutch Facings • Asbestos Textiles • Mechanical Packings • Engineered Plastics • Sintered Metal Products • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

For more facts circle 226 on Reader Service card, p 123



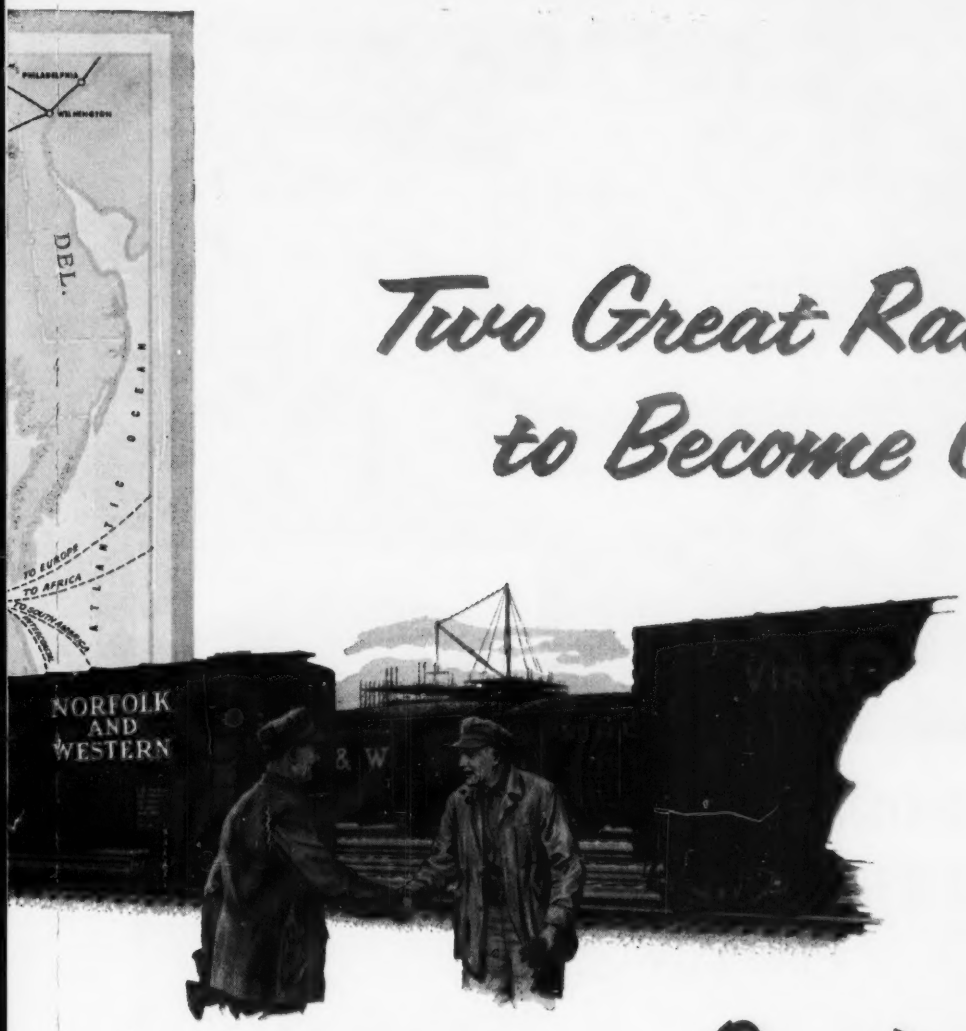
this is today's Norfolk

The first merger of two major, independently operated railroads in modern times is a reality. The historic merger of the Virginian Railway into the Norfolk and Western Railway has been approved by the Interstate Commerce Commission.

The bigger, stronger and more efficient Norfolk and Western has two principal objectives. First, the railroad will provide more efficient and improved service to the coal industry and users of coal, and to other industry and business along its lines and throughout the nation. Second, it will make available to industry a number of choice new plant sites. The territory of these sites will offer industry an abundance of low-cost power, ample industrial water, huge supplies of superior, all-purpose Bituminous Coal, high quality limestone and a great variety of other raw materials; nearness to the big consuming markets of the Southeast, Middle West and North, and overseas markets through the modern ice-free Port of Norfolk on famed Hampton Roads, plus stable, home-rooted manpower, reasonable taxes and communities that are friendly to industry. With an enlarged and strengthened industrial development department, the railroad will go all out to attract new industries to the expanded territory of the six progressive states it serves.

The merger of the two railroads makes the Norfolk and Western one of the financially strongest and most efficiently operated trunk lines in the United States, with excellent connections to the four points of the compass. This strategically

Norfolk



Two Great Railroads to Become One

and Western . . . On the Go!

located rail system has 2,747 miles of road, 5,870 miles of track . . . nearly a billion dollars in assets . . . 81,000 freight cars — more freight cars per mile of line than any other railroad in the United States 250 miles or more in length . . . the nation's newest and most modern fleet of diesel locomotives . . . up-to-date signalling and communications systems . . . huge Tidewater terminals and many other top-notch facilities.

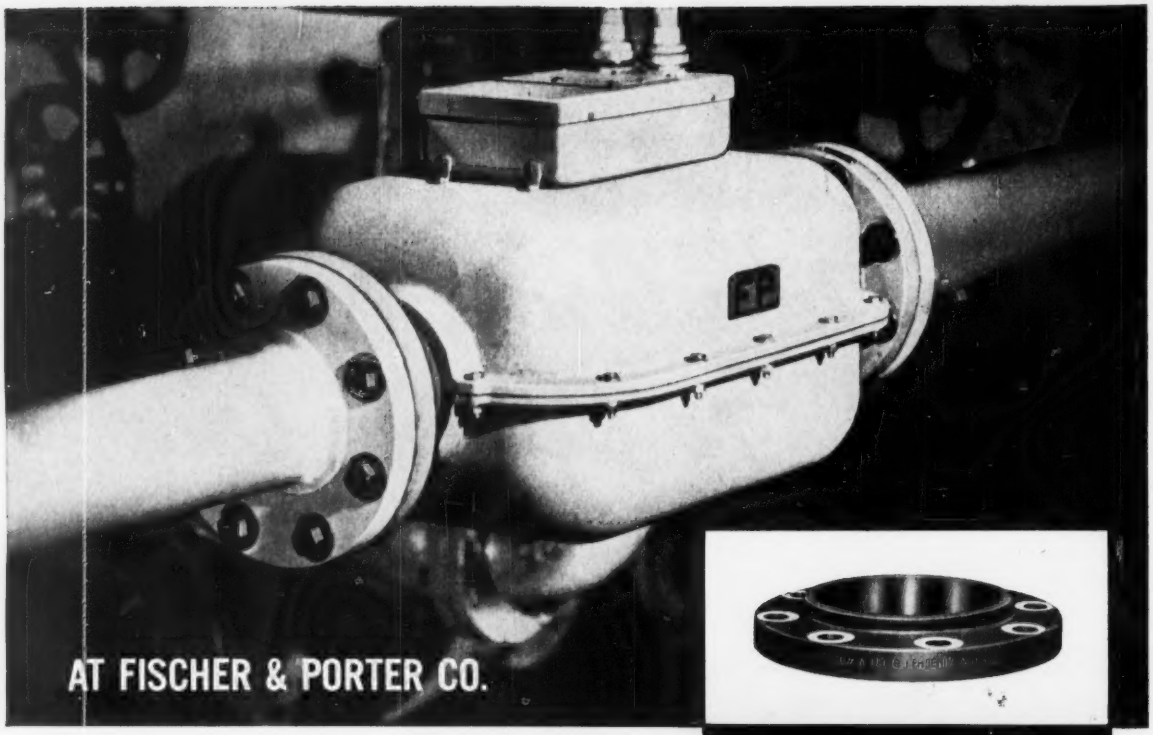
Physical consummation of the two railroads with extensive improvements will get underway as soon as possible. The Norfolk and Western looks forward eagerly to taking full advantage of the bright opportunities in the dynamic years ahead.

Statement by Stuart T. Saunders, N&W President:

"The Interstate Commerce Commission's approval of the merger is a landmark decision which signals a new day in the progress and development of greater efficiency and better service by the combined railroads. It reflects a farsighted viewpoint on the part of the Commission and a sympathetic interest in solving one of the major problems which confront the railroad industry today — the elimination of duplicating and unneeded transportation facilities and services. The Norfolk and Western expresses sincere appreciation to those progressive industries and individuals, civic groups and other organizations whose wholehearted endorsement helped to make this historic merger possible. It is an invigorating challenge, and opens a new era for the new system. The bigger, stronger and more efficient Norfolk and Western is on the go. The railroad has the facilities, the know-how, the determination and vigor to meet the challenge — to do the job."

and Western Railway

For more facts circle 227 on Reader Service card, p 123



. . . A Partnership in Quality

MAKES POSSIBLE A NEW FLEXIBILITY IN FLOWMETERING

Fischer & Porter, noted for their quality metering devices, manufacture Magnetic Flowmeters used by all industries where accurate flow measurement is required. Accuracy can be held to plus or minus 1% even under the most difficult operating conditions. At their plant in Hatboro, Penna. their design, engineering, production and purchasing departments all demand quality and service. That's why Phoenix pipe flanges have been specified and relied upon for years.

Specify Phoenix too. You can't buy a better flange.

PHOENIX FLANGES

YOU GET ALL THIS IN PHOENIX FLANGES:

- **Forged Steel. Shot Blasted.**
- **Full A.S.A. Specifications—Carbon Steel and Alloy.**
- **Spot-faced Bolting Surfaces, Extra Fine Facings, Accurate Threading and Protective Coating**
- **Serrated Gasket Surface Finish Is Standard On ALL Flanges With Raised Facings**
- **Precisely Machined Welding Bevel**
- **Special Facings, Bores, Drilling, Threading and Special Machining**

Leading Manufacturers of Pipe and Tank Flanges and Commercial Forgings

PHOENIX

FLANGE AND FORGING DIVISION

PHOENIX MANUFACTURING COMPANY

DIVISION—UNION TANK CAR COMPANY

CATASAUQUA, PA. · JOLIET, ILL. · FOUNDED 1882

PHOENIX DIVISIONS: FLANGE AND FORGING DIVISION, STEEL MILL DIVISION, HORSESHOE PRODUCTS DIVISION, FABRICATING REBAR DIVISION

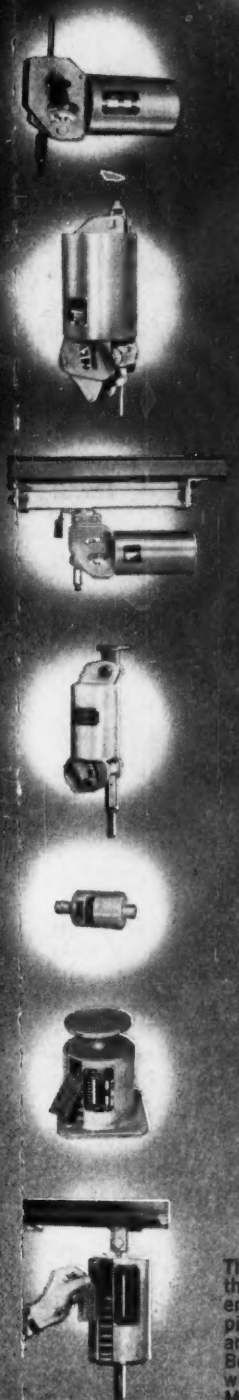
For more facts circle 228 on Reader Service card, p 123

circle 229 on Reader Service card, p 123 ➤

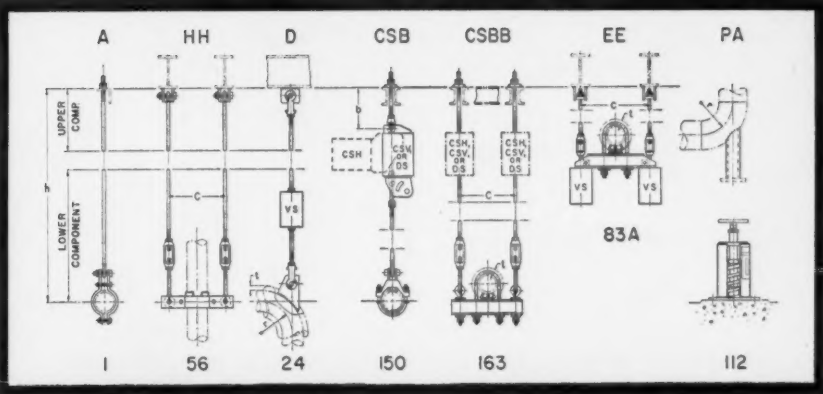
FOR SUPPORTING PIPING IN POWER, CHEMICAL, REFINERY, SHIPBUILDING AND NUCLEAR FIELDS,

USE...

THE BERGEN SYSTEM



The Bergen System utilizes standard components assembled to obtain infinite combinations to answer piping and plant engineering and equipment support problems.



The Bergen System provides these advantages:

- Complete coverage in the field of supports
- Efficient and economical pre-engineered supports
- Spring devices that are preset to cold position and may be used as rigid hangers, eliminating the need for temporary supports
- Delivery to job site of complete assemblies ready for quick, easy installation

The Bergen System is precisely accurate yet easy to use at great savings in engineering time and costs. With the system, complete assemblies or parts can be designed and/or ordered by tabulating — using simple code marks. This eliminates detail drawings and reduces field costs.

For example, using the Bergen System a complete assembly can be specified as follows:

6 D 150–10"
H = 8'9"

A thorough explanation of the meaning and use of the System is given in the new Bergen catalog.

By just providing us with your piping and equipment drawings, Bergen can supply a complete hanger design service in conjunction with the fabrication of plant-assembled hangers.

BERGEN PIPESUPPORT CORP.

50 Church Street • New York 7, New York

The Bergen '59 Catalog contains the most advanced and complete engineering data in the field of piping and equipment supports and is the key that unlocks the Bergen System for you. Copies will be sent upon request. Mail coupon today!

BERGEN PIPESUPPORT CORP.
50 Church Street, New York 7, N. Y.

Please send me a copy of your 96 page Catalog No. 59

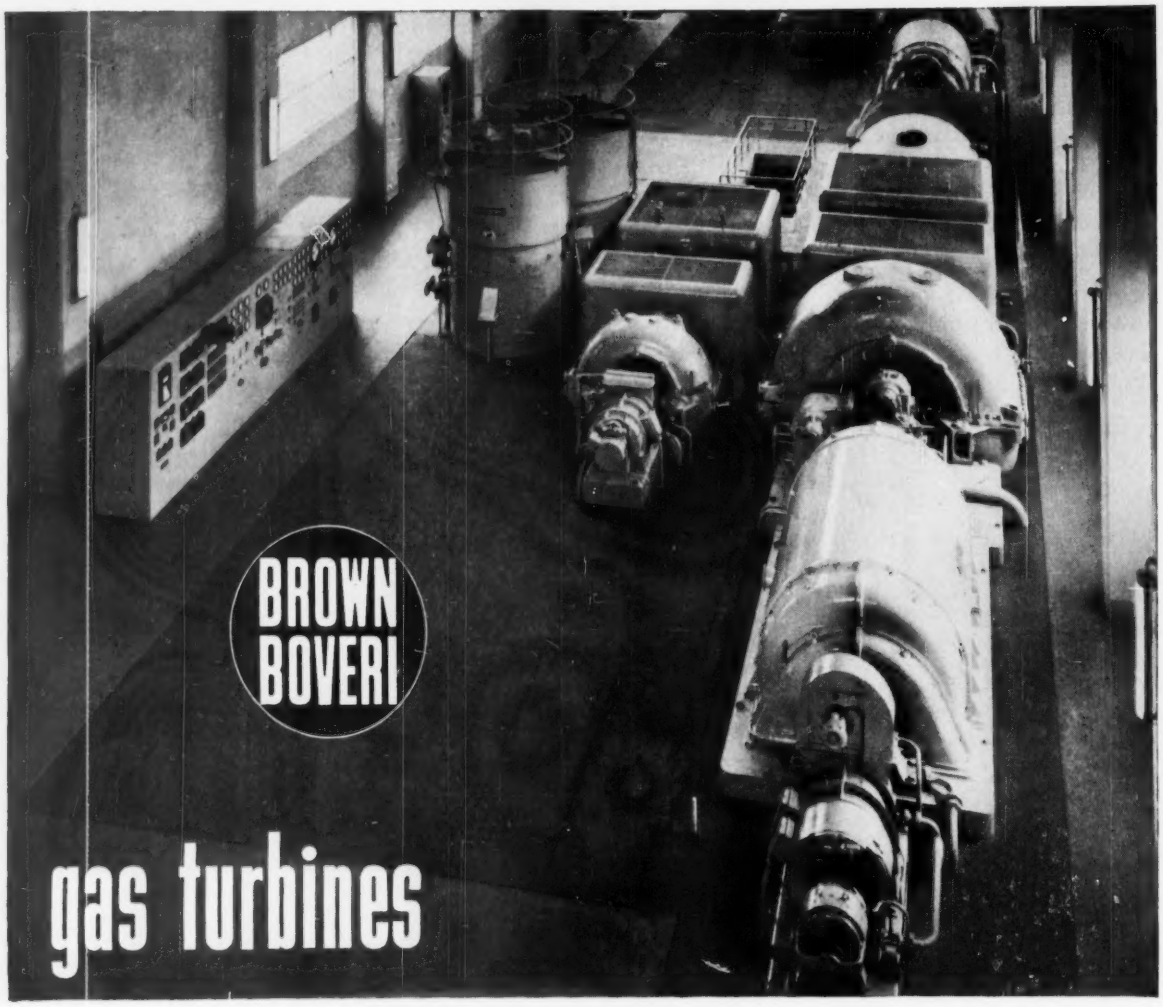
NAME _____

TITLE _____ JOB FUNCTION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



our 100th gas turbine now being built for MOORHEAD, MINN.

OVER 1,300,000 KW in total gas turbine capacity built or on order for industrial and utility applications, including 16 units in the United States, Puerto Rico and Canada with a maximum capacity of over 300,000 KW . . . *experience unmatched by any other manufacturer.*

PROVEN DEPENDABILITY AND ECONOMY of Brown Boveri gas turbines has been established in many years of operation in installations the world around, often under extremely adverse conditions.

STANDBY AND PEAKING POWER — The 7,400 KW Brown Boveri gas turbine (with a bonus wintertime capacity of up to 10,000 KW) purchased by the Moorhead municipal utility is tailormade for the city's peaking and standby requirements. Brown Boveri gas turbines offer many unique and proven advantages in this type of application.

POWER FACTOR CORRECTION using the generator as a synchronous condenser. A specially-developed coupling, exclusive with Brown Boveri, makes it possible to disconnect the generator from the turbine and reconnect it again at full speed whenever power generation is needed.

BASE LOAD OPERATION — Backed by a long record of engineering and production firsts, Brown Boveri gas turbines have been an unqualified success in many base load applications. And on the engineering horizon is the use of gas turbines in combination with steam cycles for even more efficient base load performance.

BROWN BOVERI CORPORATION

19 Rector Street, New York 6, N. Y.

Atlanta • Birmingham • Boston • Buffalo • Charlotte • Chicago • Cleveland • Dallas • Denver • Detroit • Hamilton, Ohio • Jacksonville
Kansas City • Knoxville • Miami • New Orleans • New York • Pasadena • Pittsburgh • Portland • Roanoke • San Francisco
San Juan • Syracuse • Tucson

For more facts circle 230 on Reader Service card, p 123

REDUCED MAINTENANCE
BETTER VISIBILITY

DIAMOND
Multi-Port
Bi-Color Gauges

MODEL 1050 MULTI-PORT
For boiler pressures up to 1050 psig.
Vision length—5 port—12⅜" and 7 port—18". Longer vision lengths easily obtained by adding 18" or 12⅜" sections for necessary length.

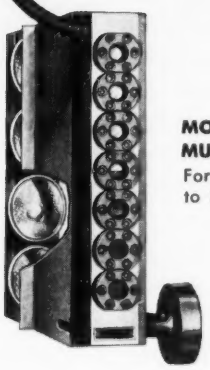
SMALL ROUND PORTS INSTEAD OF LONG GLASS AND MICA STRIPS

GAUGE NEVER REMOVED FROM BOILER FOR GASKET CHANGES OR OTHER NORMAL MAINTENANCE

STEAM SHOWS RED
WATER SHOWS GREEN

COMPLETE PORT CHANGE REQUIRES ONLY ABOUT 15 MINUTES

EACH PORT THERMALLY INDEPENDENT



MODEL MP-3000 MULTI-PORT
For boiler pressures up to 3000 psig.

Note These Features:

- **Less Maintenance — Greater Availability — Ports seldom need changing.**
- **Thermal Stability — Warm-up in minutes instead of hours.**
- **Ports are 1⅛" diameter on MP 1050 Gauge.**
- **Gauge body machined from a solid block of stainless steel. Welded tube and flange connections.**
- **"Hi-Lite" Illuminator — More visibility with less cleaning.**

The individual glass disks provide inherent thermal stability not obtained in the continuous vision gauge which requires the long glass and mica. Thermal stress is much less troublesome and damaging. Small mica disks cost less, and are not subject to wrinkling or cracking. Any port — glass, gasket and mica — may be replaced in minutes without removing the gauge from the boiler. Torquing operations are much less critical, and warm-up period is minutes instead of hours.

The Bi-Color feature makes reading sure. By an invariable optical principle, steam always shows red, water green. Changes in level show instantly. 8302

For a trouble-free gauge that makes reading of water level sure and easy — Diamond Multi-Port Bi-Color —

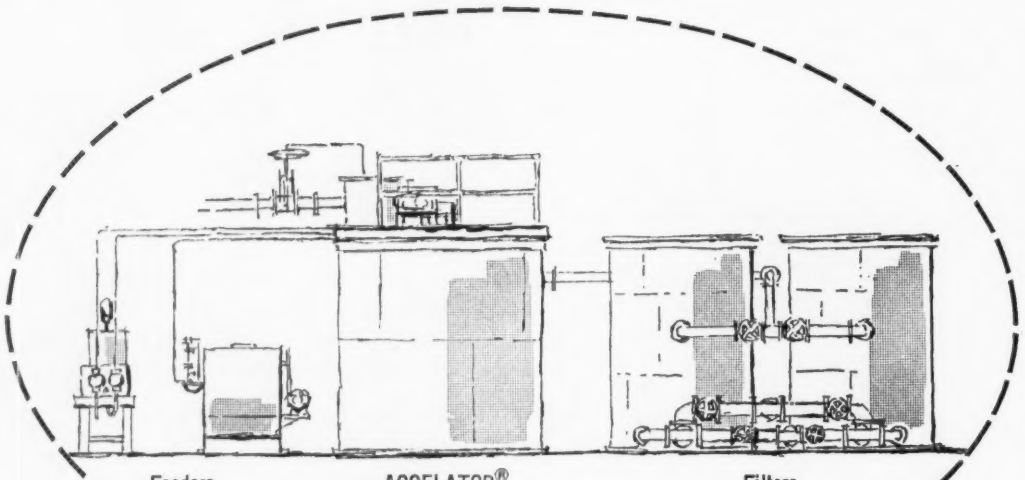
Write for

Bulletin 2044-A for pressures up to 1050 psig
Bulletin 1174 for pressures up to 3000 psig

DIAMOND POWER SPECIALTY CORPORATION
LANCASTER, OHIO • DIAMOND SPECIALTY LIMITED - *Windsor, Ontario*

For more facts circle 231 on Reader Service card, p 123

A complete "package" water treating plant...



the

ACCELAPAK®

plant

COMPLETE—from inlet to outlet—nothing else required.

ADAPTABLE—for clarification, softening, iron or color removal, and sterilization. Pressure or gravity filters, as required.

STANDARDIZED—pre-engineered in all sizes with standardized dimensions in capacities from 15 to 350 gpm.

SIMPLE—working parts, easily accessible for minimum required attention. Simple erecting and operating instructions.

DEPENDABLE—treatment results are easily obtained; uniformly and dependably maintained.

ECONOMICAL—costs of plants are low due to quantity purchasing and production; installation space is small; maximum utilization of treating chemicals is assured.

9401

Write today for full details on the "ACCELAPAK" plant in Bulletin 1870-A or request Bulletin 80 showing our complete line of water and waste treating equipment.

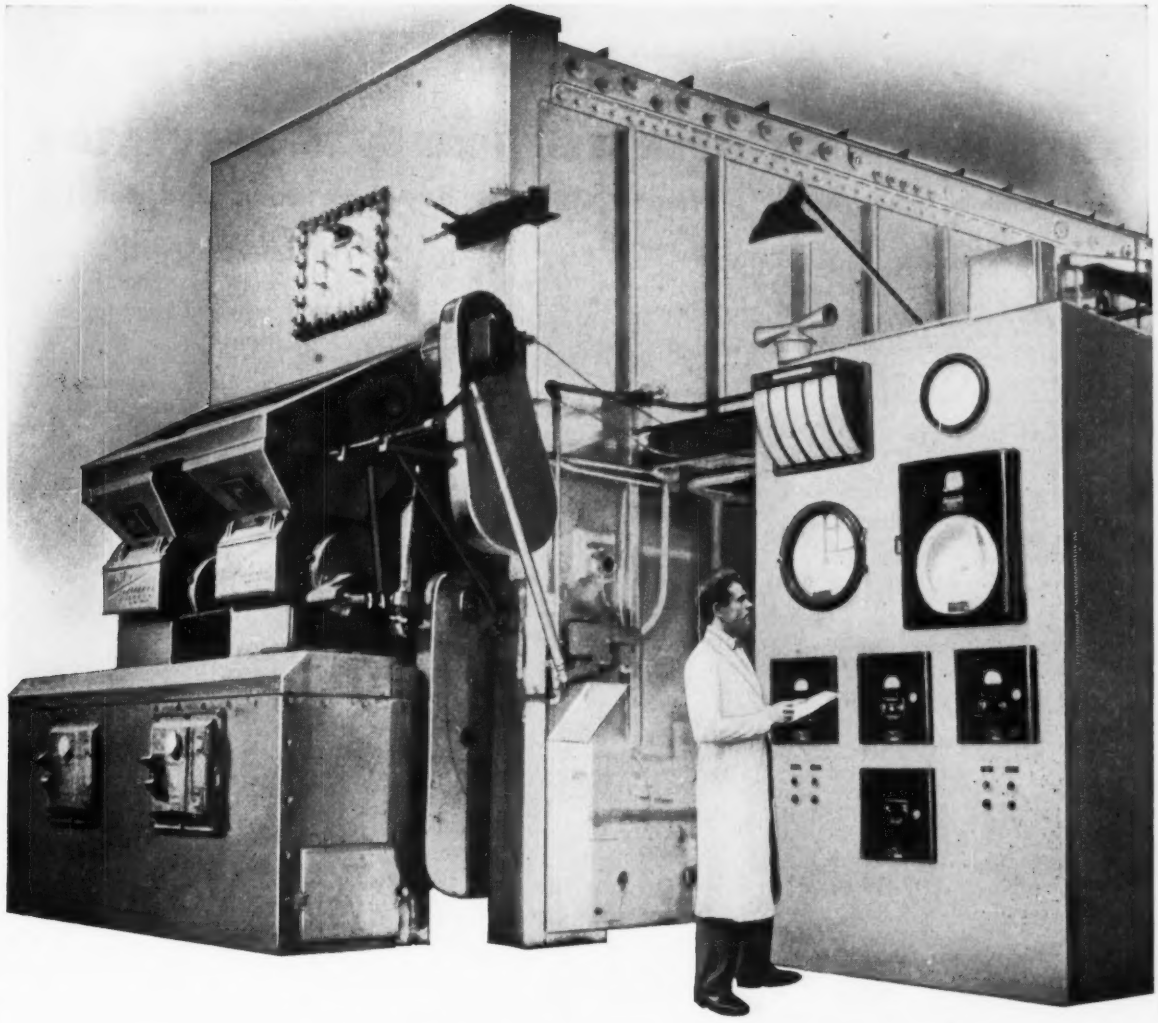
INFILCO

INFILCO Inc.

General Offices, Tucson, Arizona

Field offices throughout the United States and other countries.

For more facts circle 232 on Reader Service card, p 123



Now a stoker fired steam generator with the advantages of a heat engineered "package"

The same engineering excellence that gives standard Foster Wheeler oil and gas fired steam generators their convenience, dependability and economy is built into this new, stoker-fired packaged unit.

It is designed for semi-automatic operation, comparable with the newest gas and oil fired packaged steam generators. The push of a button can bring it on or off a banked fire. The firing front can be converted for oil firing over a weekend. Shipment in three major subassemblies materially reduces the amount of labor as compared to field erection of coal burning steam generators of similar capacity.

In brief, this new packaged steam generator is everything you would expect from the company that originated the "steam package concept". In a series of exhaustive tests, the new unit has exceeded all expectations for capacity and efficiency.

If you are in an area where coal would be your most economical fuel, you will find it well worth your while to get full information on Foster Wheeler's new stoker fired packaged steam generator before writing specifications for any new steam generating installation. It is available in three standard sizes: 43,000 lb, 50,000 lb and 63,000 lb of steam per hour at 250 psi. Or, if an oil or gas fired unit would be more suitable, get specifications on Foster Wheeler's full line of packaged steam generators in capacities from 13,000 lb/hr to 100,000 lb/hr.

Heat Engineered products, plants and processes . . . for the world's industrial progress.

Write to: Foster Wheeler Corporation, 666 Fifth Ave., New York 19, N. Y.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

For more facts circle 233 on Reader Service card, p 123

NEW... from K&M

EXTERNAL PILOT-OPERATED PRESSURE REGULATOR

fast-acting, accurate . . . tight shut-off even on dead-end service

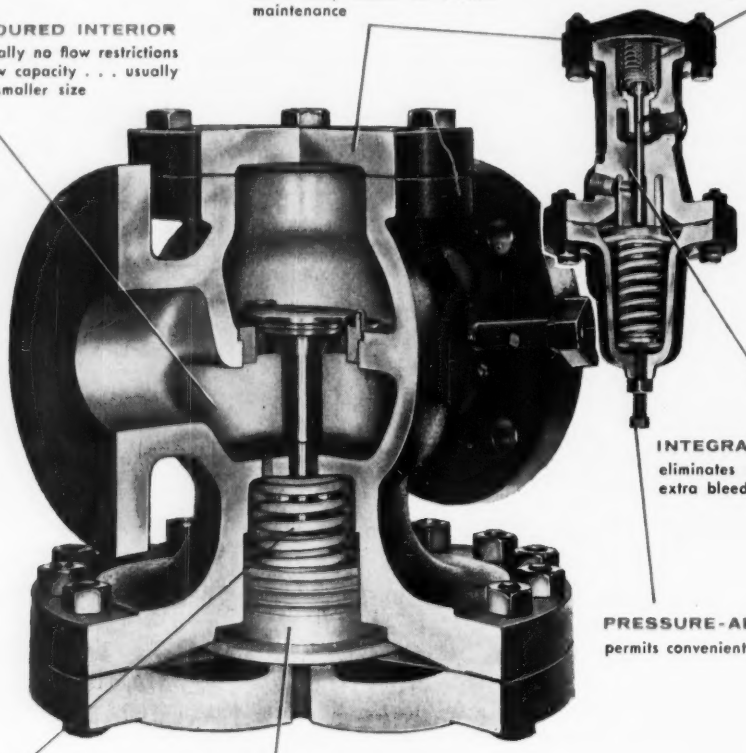
Examine it yourself . . . feature for feature. K&M has made a vast improvement in external pilot-operated pressure regulators.

It simplifies installations: *requires one less pipe line.* It offers lowest maintenance: *the result of good hydraulic and mechanical design throughout.* It gives excellent performance: *try one and compare with any other regulator of its type.*

BUILT-IN STRAINER
protects pilot from scale, dirt, other foreign matter, is removable for cleaning

BLIND FLANGES
on both main valve and pilot allow easy access for routine maintenance

CLEANLY CONTOURED INTERIOR
has no spider, practically no flow restrictions . . . gives greater flow capacity . . . usually permits economy of smaller size



INTEGRAL BLEED ORIFICE
eliminates need for installation of extra bleed line

PRESSURE-ADJUSTING SCREW
permits convenient external pressure setting

GUIDE PISTON
has balancing grooves which hydraulically center guide, prevent binding and side-thrust

CONTROL SPRING
is isolated from main flow stream for greatest protection

If you would like a more detailed, close-up look at K & M's new Type 471 External Pilot Pressure Regulator, send for Bulletin 471A.

K&M diaphragm control valves®

KIELEY & MUELLER, INCORPORATED

Our 79th Year

Oldest Pressure and Level Control Valve Manufacturer
64 Genung Street, Middletown, New York

S.A. 1808

For more facts circle 234 on Reader Service card, p 123

THE 1960 NATIONAL PLANT MAINTENANCE & ENGINEERING SHOW

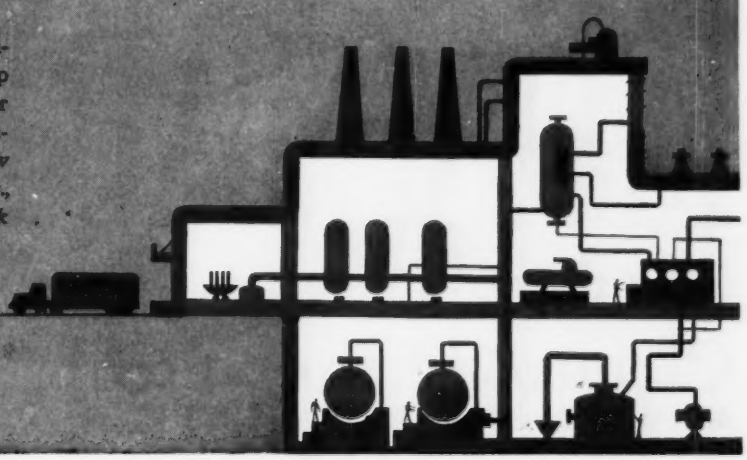
Four idea days that will stimulate your thinking and freshen your approach to the job of increasing plant efficiency. Almost 400 leading manufacturers will show you machines, equipment, supplies and services covering every aspect of plant and maintenance engineering. All under one roof, at one time! See and compare, discuss your problems with experts!

At the Plant Maintenance & Engineering Conference you'll hear top experts discuss your problems. For show registration tickets and conference information, write to: *Show Management, Clapp & Poliak, Inc., 341 Madison Avenue, New York 17, N. Y., MUrray Hill 4-3432.*

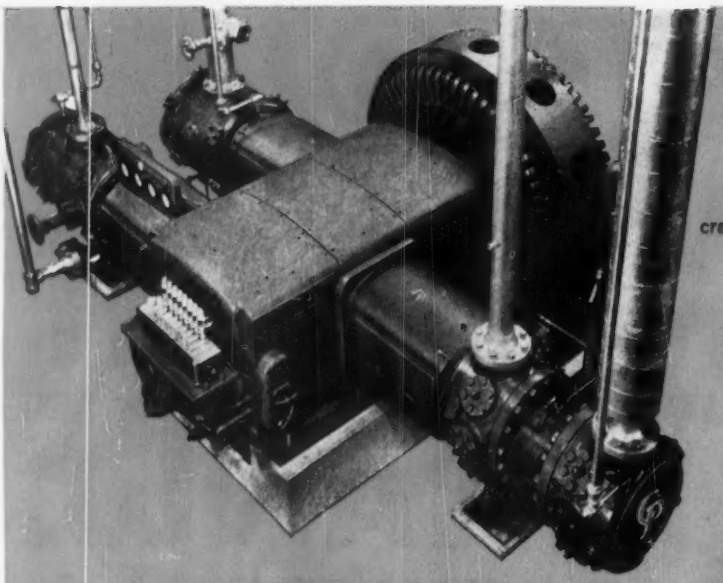
CONVENTION HALL, PHILADELPHIA

JANUARY 25-28, 1960

DON'T MISS THE CONFERENCE

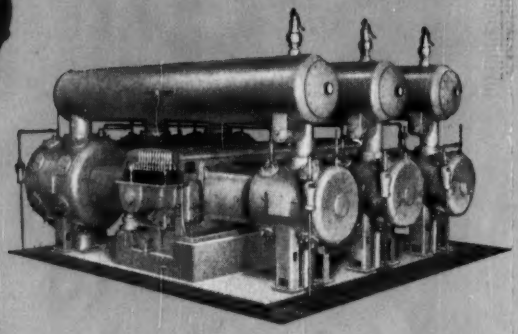


For more facts circle 235 on Reader Service card, p 123

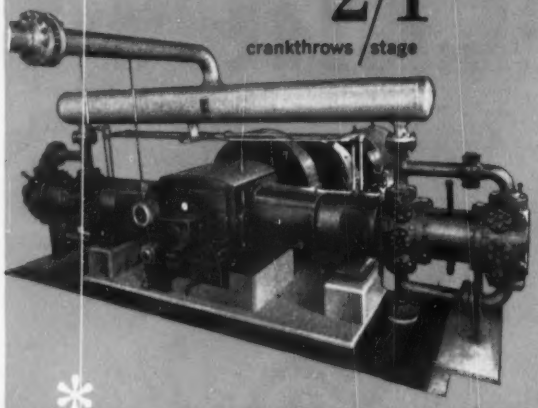


*3/3
crankthrows/stages

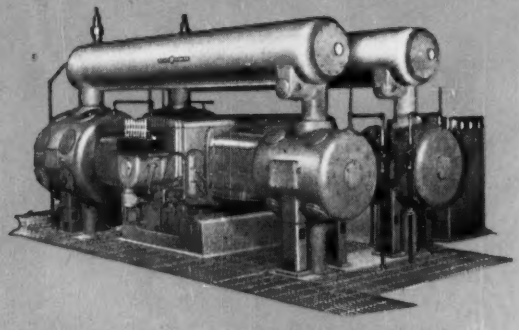
*6/2
crankthrows/stages



*2/1
crankthrows/stage



*4/2
crankthrows/stages

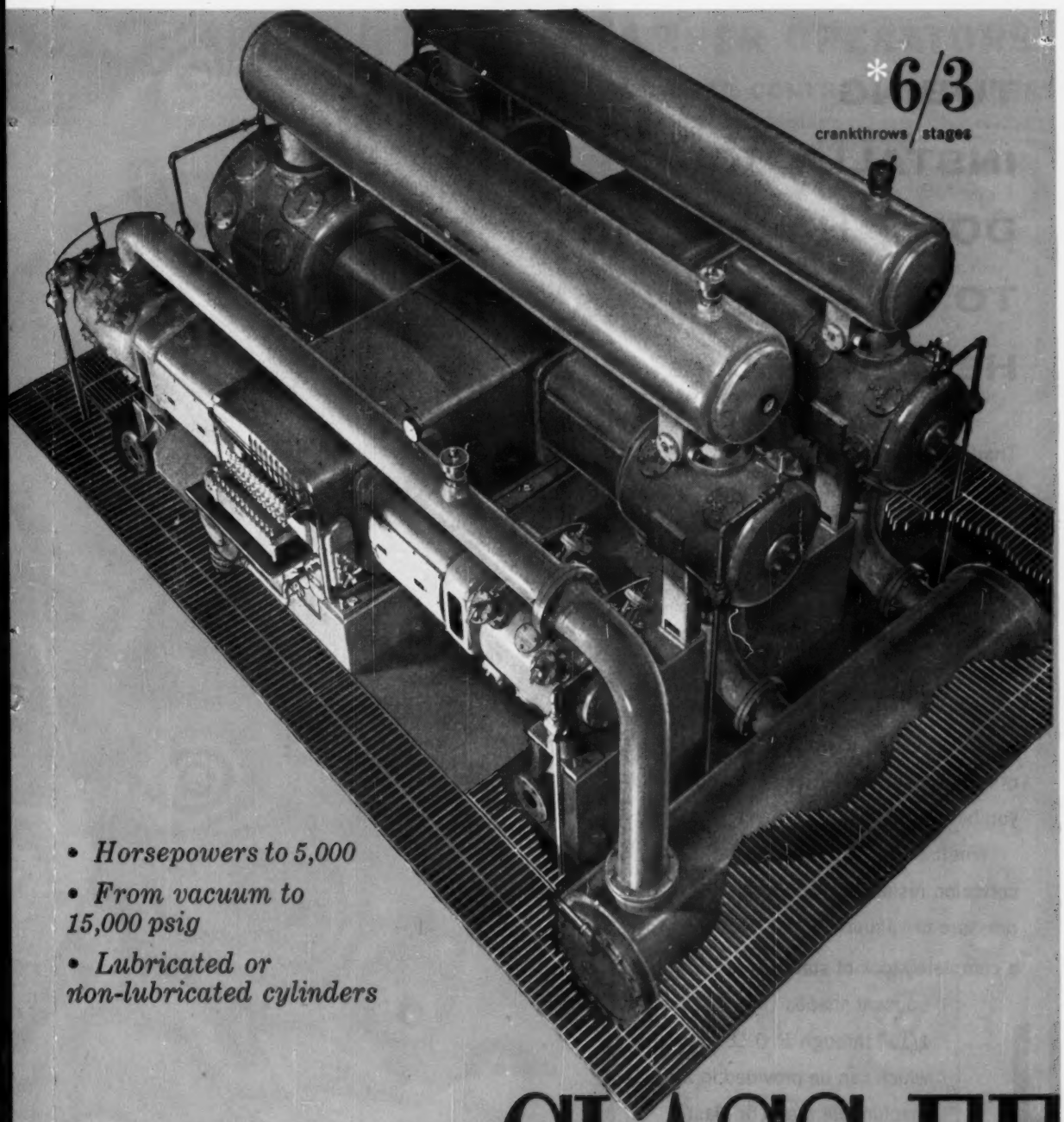


*Typical of the many combinations of compressor crankthrows, cylinder arrangements and staging that give you the perfect compressor for every process requirement.

ADAPTABILITY...

Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS



- *Horsepowers to 5,000*
- *From vacuum to 15,000 psig*
- *Lubricated or non-lubricated cylinders*

at its best in CLASS FE COMPRESSORS

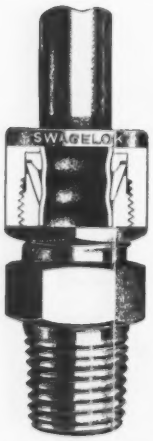
For more facts circle 236 on Reader Service card, p 123

TUBING INSTALLATIONS DON'T HAVE TO BE A HEADACHE!

That's a pretty broad statement, but there is absolutely no reason why you have to live with the most minute leak in your tubing installations. Nor is there any reason why you have to suffer the slightest inconvenience in obtaining the most dependable tube fitting in a particular size, shape or material needed to provide the type of leakproof, trouble-free installation you have every right to expect!

Whether your application involves corrosion resistance, temperature, pressure or vacuum, SWAGELOK has a complete stock of standard and unusual shapes (in sizes for 1/16″ through 1″ O.D. tubing) which can be provided in **any** machinable metal or plastic.

Write for our latest, complete Swagelok catalog.



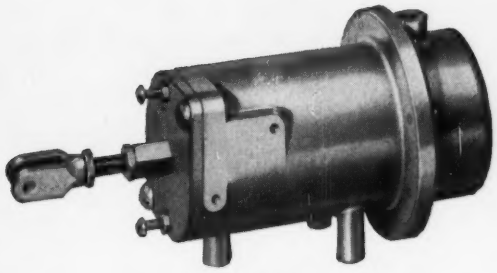
Swagelok® TUBE FITTINGS

CRAWFORD FITTING COMPANY
884 East 140th Street • Cleveland 10, Ohio
Crawford Fittings (Canada), Ltd. • Niagara Falls, Ontario, Canada

For more facts circle 237 on Reader Service card, p 123

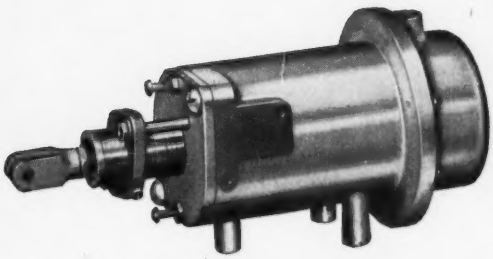
JOHNSON PISTON-TYPE DAMPER OPERATORS

ASSURE MAXIMUM POWER FOR ACCURATE CONTROL OF DAMPERS



D-251 Piston Damper Operator

- Powerful, long-stroke design. Allows damper to be operated *directly* from piston rod for accurate, positive positioning. No linkage or levers to lessen power. Outperforms conventional operators.
- Simple, trouble-free construction. Spring and diaphragm are fully enclosed. Powered by molded rubber diaphragms which are age- and heat-resistant.
- Adjustable stops permit limiting stroke in either direction.
- May be mounted in any position on damper frame, wall, or duct.
- Attractive die-cast, non-corrosive body.
- Size Nos. 2, 3, 4, and 6.

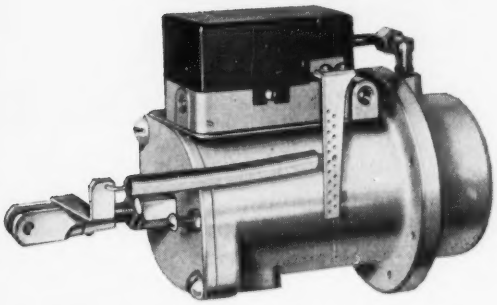


D-255 Two-Stage Piston Operator

Designed especially for unit ventilator applications, the D-255 two-stage operator has the same general features as D-251 plus:

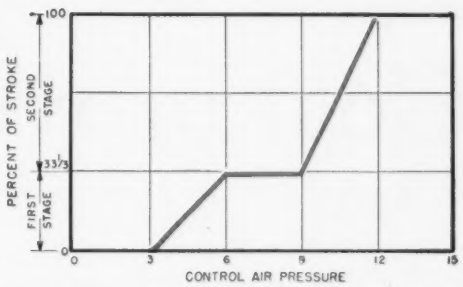
- Two-stage operation (see chart below). First stage is adjustable 0 to 50 per cent of total stroke.
- Compact, fits all unit ventilators. No. 3 size only.
- Choice of molded rubber or molded silicone diaphragms. Heat- and age-resistant.
- Self-lubricating Nylon insert stem guide.

For full details on the Johnson equipment shown here, write for Bulletins D-251, D-255 and D-265. Johnson Service Company, Milwaukee 1, Wisconsin.



D-265 Pilot Positioner Applied to D-251 Piston Damper Operator

The D-265 Pilot Positioner provides maximum and accurate repositioning power in response to very small changes in pressure from the controlling instrument. Assures proper operation independent of friction, changes in air velocities, or other variables. May be applied to all sizes of D-251 operators.



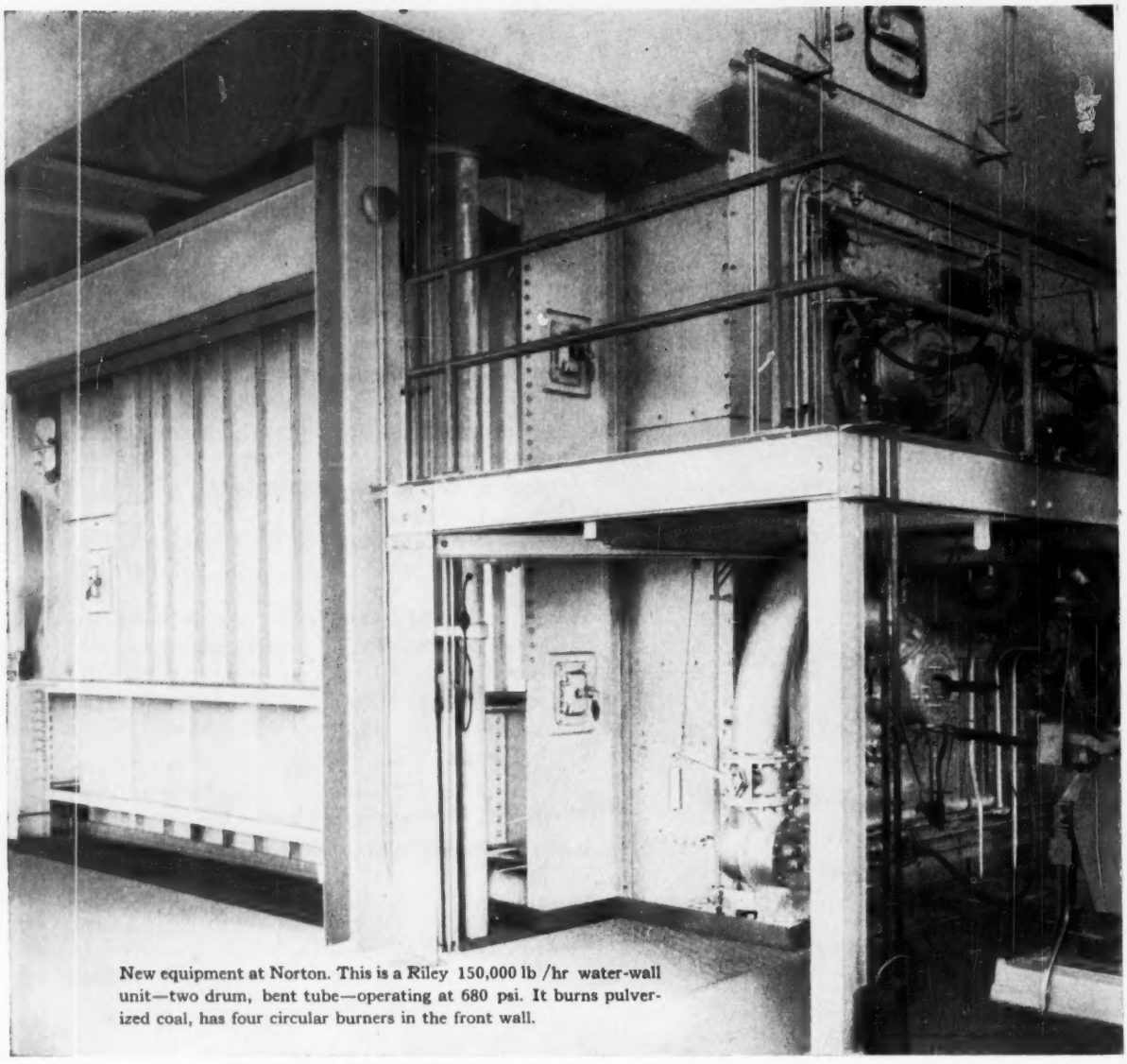
Relationship between stroke and control air pressure of D-255 Two-Stage Piston Operator.

JOHNSON CONTROL

PNEUMATIC SYSTEMS

DESIGN • MANUFACTURE • INSTALLATION • SINCE 1885

For more facts circle 238 on Reader Service card, p 123



New equipment at Norton. This is a Riley 150,000 lb /hr water-wall unit—two drum, bent tube—operating at 680 psi. It burns pulverized coal, has four circular burners in the front wall.

Coal proves best dollar

NORTON COMPANY FINDS COAL STILL IS LOWEST COST

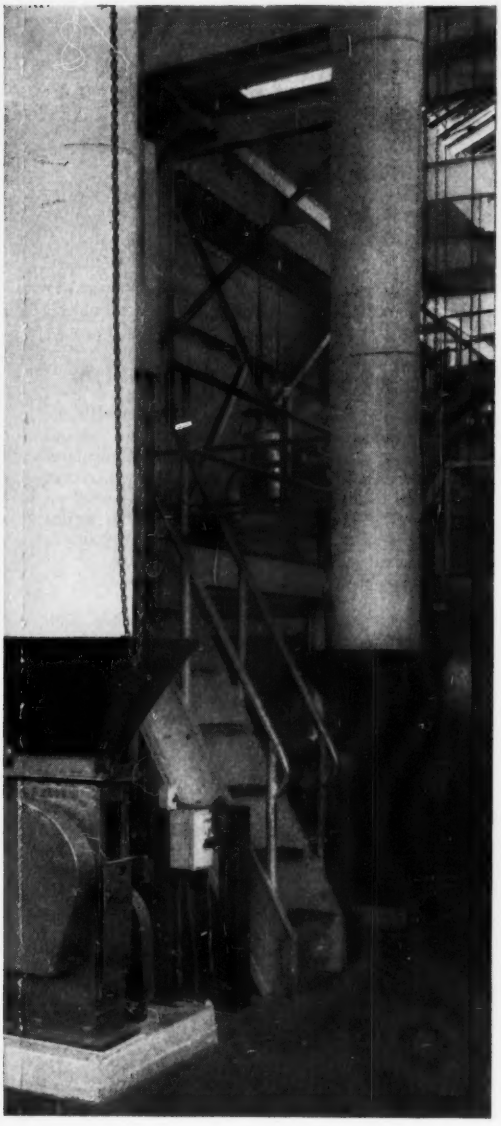
As plant facilities expanded, the Norton Company, Worcester, Mass., world's largest manufacturer of abrasive products, required greater quantities of steam for heating, hot water, electricity and process work. This expansion prompted an engineering survey to determine future power needs. As a result, Norton staff engineers—working with K. R. Warrington, Consulting Engineers—decided to install additional steam generating equipment. Coal had been used previously because it was the most economical of the fuels in that area when the original plant was installed. Coal *continues* as the fuel of the new plant for the same reason. Norton management is sold on the fact that, dollar for dollar, coal is the best fuel buy.

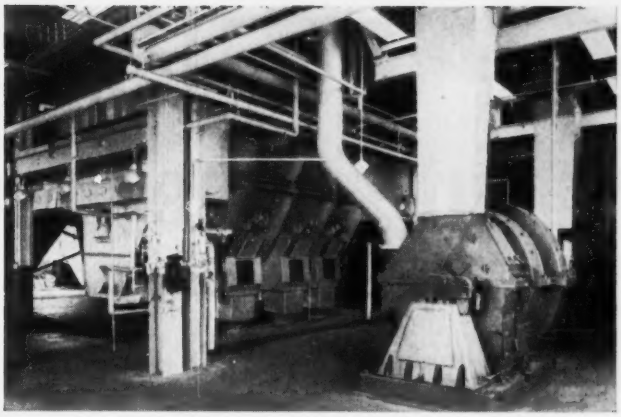
COAL IS LOWEST COST FUEL

Today, *when the annual cost of fuel often equals the original cost of the boilers,* you should know that bituminous coal is the lowest cost fuel in most industrial areas. And modern coal-burning equipment gives you 15% to 50% more steam per dollar, while automatic operation trims labor costs and eliminates smoke problems. What's more, tremendous coal reserves and mechanized mining procedures assure you a constantly plentiful supply of coal at stable prices.

CONSULT AN ENGINEERING FIRM

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel





In the center, ash hoppers—part of United Conveyor steam vacuum ash handling system—lead to underground conveyor which moves ashes to outside storage silo. At right: coal pulverizers.

From track hopper, 100 ton/hr boom conveyor (right) carries coal to storage area. Bucket conveyor (center) lifts it to belt conveyor at top of plant. Coal handling system by William T. Donovan Co. and Jeffrey Manufacturing Co.

buy

FUEL IN ITS AREA

costs and equipment—can effect great savings for you with the efficiency and economy of coal.

TECHNICAL ADVISORY SERVICE

To help you with fuel problems, the Bituminous Coal Institute offers a free technical advisory service. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to address below or send coupon. Ask also for case histories booklet, complete with data sheets. You'll find them informative.

BITUMINOUS COAL INSTITUTE

Department P-12 , Southern Building, Washington 5, D. C.

See our listing in Sweet's Files: A-30J/Bi; PE-4a/Bi; 1C-18b/Bi

SEND COUPON FOR NEW BCI PUBLICATIONS
Guide Specifications, with complete equipment criteria and boiler room plans:

Bituminous Coal Institute, Dept. P-12
Southern Building, Washington 5, D. C.

Gentlemen: Please send me:

☐ GS-1 (low-pressure heating plant, screw-type underfeed stoker).

☐ GS-2 (high-pressure heating and/or process plant, ram-type underfeed stoker).

☐ GS-3 (automatic package boiler for heating and process plants).

☐ Case histories on larger plants.

Name _____

Title _____

Company _____

Address _____

City _____ Zone _____ State _____

For more facts circle 239 on Reader Service card, p 123

Expansion Joint Design Moves out of the "Model T" Era

Badger first began fabricating packless metal bellows expansion joints more than 35 years ago. These "Model T" joints performed (and are still performing) with outstanding success in hundreds of process and steam line piping installations.

Starting in the 30's other expansion joint manufacturers entered the field. The most successful adopted many of the basic features of the original Badger design.

During the last decade, as industry's requirements became more stringent, and joint manufacturers gained fabricating and field experience, certain fundamental problems inherent in the early designs became evident. Most of these problems were solved through a series of modifications. (Among which was the Badger Directed Flexing Self-Equalizing Joint — the famous "DFSE" Design.) But, at best, the modifications were stop-gap measures which complicated the joints and greatly increased their weight. A fundamental reassessment of expansion joint engineering data was needed. Badger led the way: In 1956, a task force completed a three-year research program and the first S-R (Service-Rated) Expansion Joints were produced.

In the three years they have been available, S-R Expansion Joints have been both an engineering and a sales success. But like many revolutionary concepts which upset tradition, the full implication of the advantages S-R Joints offer is still not universally understood. The message that follows is an attempt "to set the record straight."

• • • • •

Equalization — fact and fiction

Many users of expansion joints are under the impression that the so-called "equalizing" rings on today's conventional type expansion joints distribute movement equally among all the corrugations of the bellows. It is argued that as the joint absorbs thermal movement, the tops of the rings progressively come into contact until the bellows is fully compressed thus limiting the amount of compression which any one corrugation can ultimately absorb (see diagram 1). In *this* sense the rings do contribute to the "equalization" of movement by physically limiting the compression of each corrugation to the distance between any two adjacent rings.

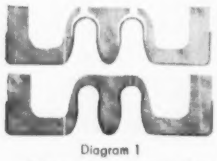


Diagram 1

Conventional Type Expansion Joint. Cross-sections of rings and bellows of a conventional "self-equalizing" joint showing cold and hot positions. Note that true equalization of movement can only be obtained when tops of all rings are in contact — an impractical and dangerous situation.

Note, however, that the degree of compression will not be truly equalized until the tops of all the rings are in contact. But, when such a condition occurs, serious problems will result. If the limit of compressibility is reached before the thermal expansion has been completely absorbed, exceedingly large forces will be transmitted through the pipe line to the anchors and connected equipment. On the other hand, if the joint is compressed only partially, not all of the corrugations will absorb movement to the same degree.

How S-R Joints solve equalization problem

Badger S-R Expansion Joints feature the new Curvilinear Corrugations which naturally assume an "all curve" shape under pressure (diagram 2), assuring more equal distribution of stresses throughout the bellows material. Furthermore, the shape, height and pitch of the corrugations are based on a carefully engineered correlation. Thus, reasonably equal distribution of movement among the corrugations is obtained, even in joints not equipped with reinforcing rings.

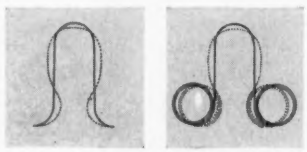


Diagram 2

Badger S-R Expansion Joint. Cross-sections of S-R Joints (Series 50 left, Series 150 right). The movement of the corrugations is shown by dotted and solid lines. Compare configuration and effective height of corrugations, position and size of rings with conventional joint.

Equalization of movement is inherent in the design and functioning of the bellows on Badger S-R Joints. On the basis of provable engineering criteria, the prime purpose of reinforcing rings of any design is to retain the hoop dimension (diameter) of the corrugations when they are subject to internal pressure. This Badger's simple, lightweight tubular reinforcing rings do. But, in addition, the new tubular shape of the rings does contribute to joint flexibility and life by permitting flexing over a more effective portion of the total corrugation height than conventional cast or fabricated equalizing rings.

Better performance, lower cost

Briefly, then, Badger S-R Joints alone offer these advantages: Better equalization of movement which results in elimination of localized stresses and leads to longer joint life; a simple, lightweight design that makes installation easier, eliminates cumbersome castings and fragile mechanical devices; complete range of sizes from 3″ to 72″ made from any workable metal and with a wide choice of accessories.

Badger S-R Joints are probably the answer to your problem. There's an easy and quick way to find out — ask the Badgerman for his recommendations. Write or phone today. Badger Manufacturing Co., 230 Bent St., Cambridge, Mass.

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BADGER S·R EXPANSION JOINTS

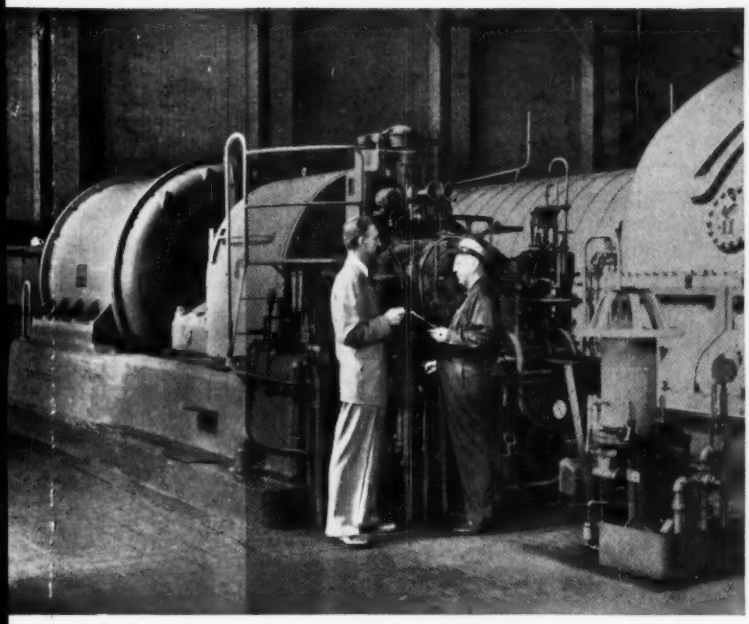
Report from Wisconsin Electric Power Company

HOW THE ONLY OIL WITH LIFE-OF-TURBINE GUARANTEE IS DOING AFTER 27 YEARS

Situation: On February 23, 1931, Wisconsin Electric Power started Turbine 12 at its Lakeside Station – a 7,700 kw. General Electric. The 550-gallon turbine oil reservoir was filled with NONPAREIL. A Standard Oil lubrication engineer was there to supervise the fill. After 30 days a framed certificate was furnished the utility. This certificate guaranteed that the NONPAREIL Turbine Oil would never exceed a level of acidity of 0.15 mg. KOH/g. for the life of the turbine.

What has happened: Analyses of oil samples have been made at regular intervals since the start-up date. The acidity level of the oil now is the same as the day it went into service –0.06 mg. of KOH per gram of oil. In the 27 years since NONPAREIL Turbine Oil was installed, Wisconsin Electric Power has added steadily to its generating capacity. NONPAREIL Turbine Oil has been installed in all turbines.

What to do: Get more information about NONPAREIL from your nearby Standard Oil industrial lubrication specialist in any of the 15 Midwest and Rocky Mountain states. Or write **Standard Oil Company (Indiana), 910 S. Michigan Avenue, Chicago 80, Ill.**



Standard Oil's Robert A. Guis and Lakeside Station superintendent, C. E. Thielman, inspect records of Turbine 12, which has been operating with NONPAREIL Turbine Oil for 27 years. Years of experience providing technical service and an engineering degree qualify Bob Guis for work with utilities on turbine lubrication. Bob has an engineering degree from the University of Wisconsin plus 18 years of this kind of work behind him. In addition, he has completed the Standard Oil Sales Engineering School.

Quick facts about
NONPAREIL Turbine Oil

- Will not permit formation of harmful acids
- Will not permit formation of sludge or oil varnish
- Will maintain good demulsibility or water separating characteristics
- Has high resistance to foaming
- Contains adequate rust inhibitor

You expect more from STANDARD and get it!

For more facts circle 241 on Reader Service card, p 123

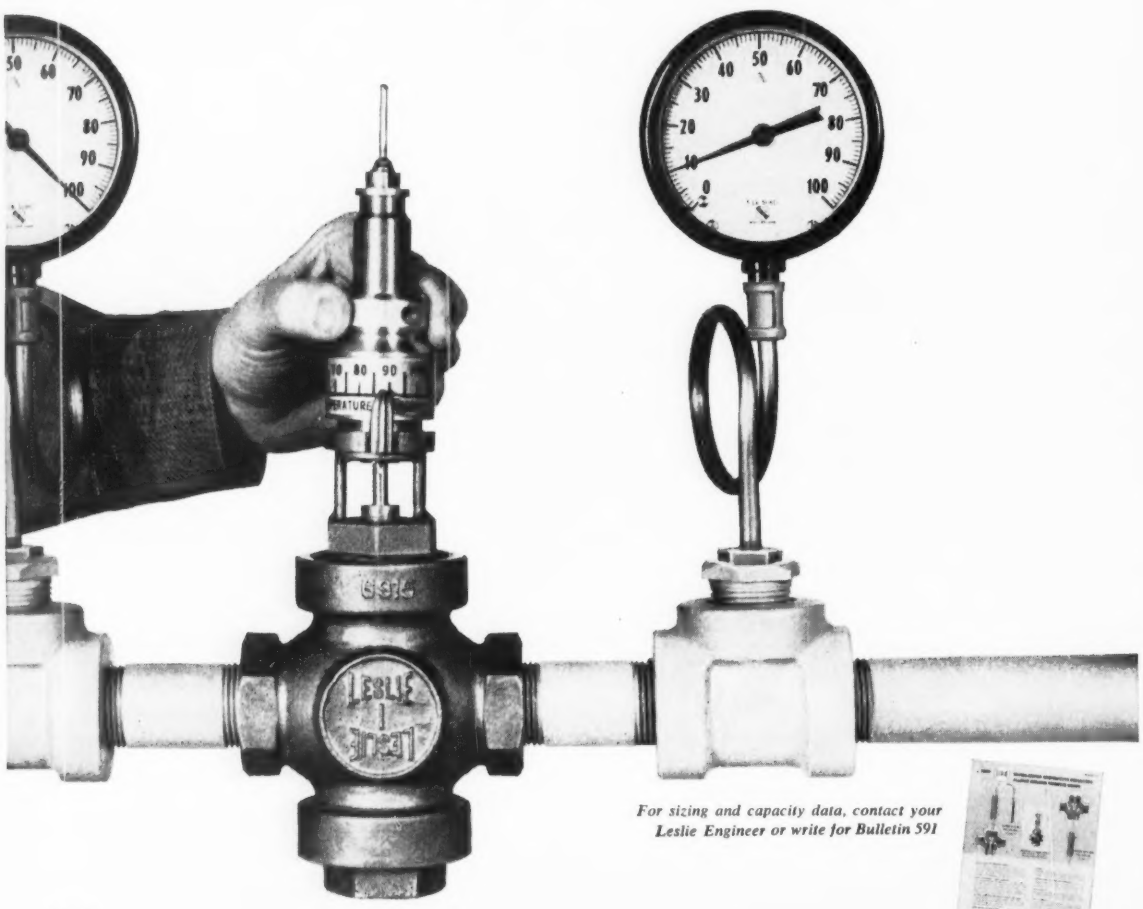
accuracy, reliability
ENGINEERED INTO LESLIE'S COMPLETE

NEW SINGLE-SEATED, BALANCED DISC, TEMPERATURE REGULATOR HANDLES INLET PRESSURES TO 100 psi.

New Leslie regulator can handle inlet pressure and pressure drops to 100 psi. High power, positive movement of an actuating bellows with solid liquid fill, and the virtually friction-less stuffing box provides stem movement exactly proportional to the temperature change at the bulb.

Designed for steam or water service, it features a single seated, self-aligning, tight closing inner valve. (Units can be changed in the field from direct to reverse acting, or from reverse to direct acting, simply by inverting body and main valve.)

Applications include instantaneous heaters or coolers—shell and tube or shell and coil heat exchangers; storage or tank heaters; and, process heaters or coolers of all types. Available in cast iron or cast bronze bodies for temperatures to 450°F. Sizes ¾ and 1", screwed connections.

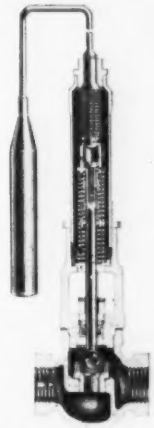


For sizing and capacity data, contact your Leslie Engineer or write for Bulletin 591

LC-10

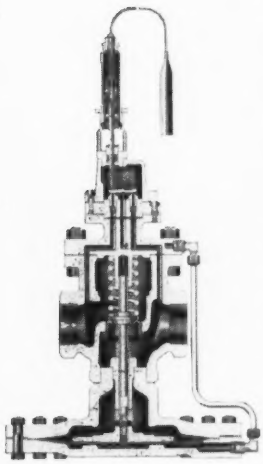
LINE OF TEMPERATURE REGULATORS.

OTHER VERSATILE LESLIE REGULATORS PROVIDE PRECISE TEMPERATURE AND PRESSURE CONTROL.



Bellows Operated Temperature Regulator For Small Flows

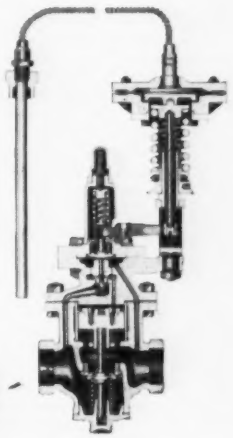
Direct Operated Design is used for small flow heating and cooling service, size ⅜, ½ and ¾". Liquid filled thermostatic element supplies ample power to stroke the single seated main valve. Valve travel is directly proportional to temperature change at bulb. This design is suitable for instantaneous and storage type heaters. It is also available in double seated construction for cooling service.



Class TKM Pilot Actuated, Metal Diaphragm Operated Temperature Regulator

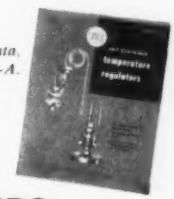
Pilot Operated, Single Element Control also uses the liquid filled element to operate pilot device which applies operating pressure from the regulator inlet to a diaphragm for stroking main valve in heating or cooling service. Large diaphragm area and operating pressure supply ample power for controlling long stroke, single seated main valve with full flow capacity in sizes ½-4". Regulator has a 3 to 5° throttling range and is suitable for all storage type heat exchangers and for any system requiring on-off control.

Class LTCO Pilot Actuated, Piston Operated Temperature Regulator



Pilot Operated, Duo-Matic (two-element control) design offers both temperature and pressure regulating functions in a pilot actuated, piston or diaphragm operated regulator. The valves can handle a range of inlet steam pressures in heating services from 25 to 600 psi and controlled pressure ranges of either 2 to 15 psi or 10 to 250 psi. These characteristics are ideal for all storage type heaters and most instantaneous heater problems. Available in sizes ¼-6" with iron, bronze and cast steel construction.

For complete sizing and capacity data, write for Bulletin 5307-A.

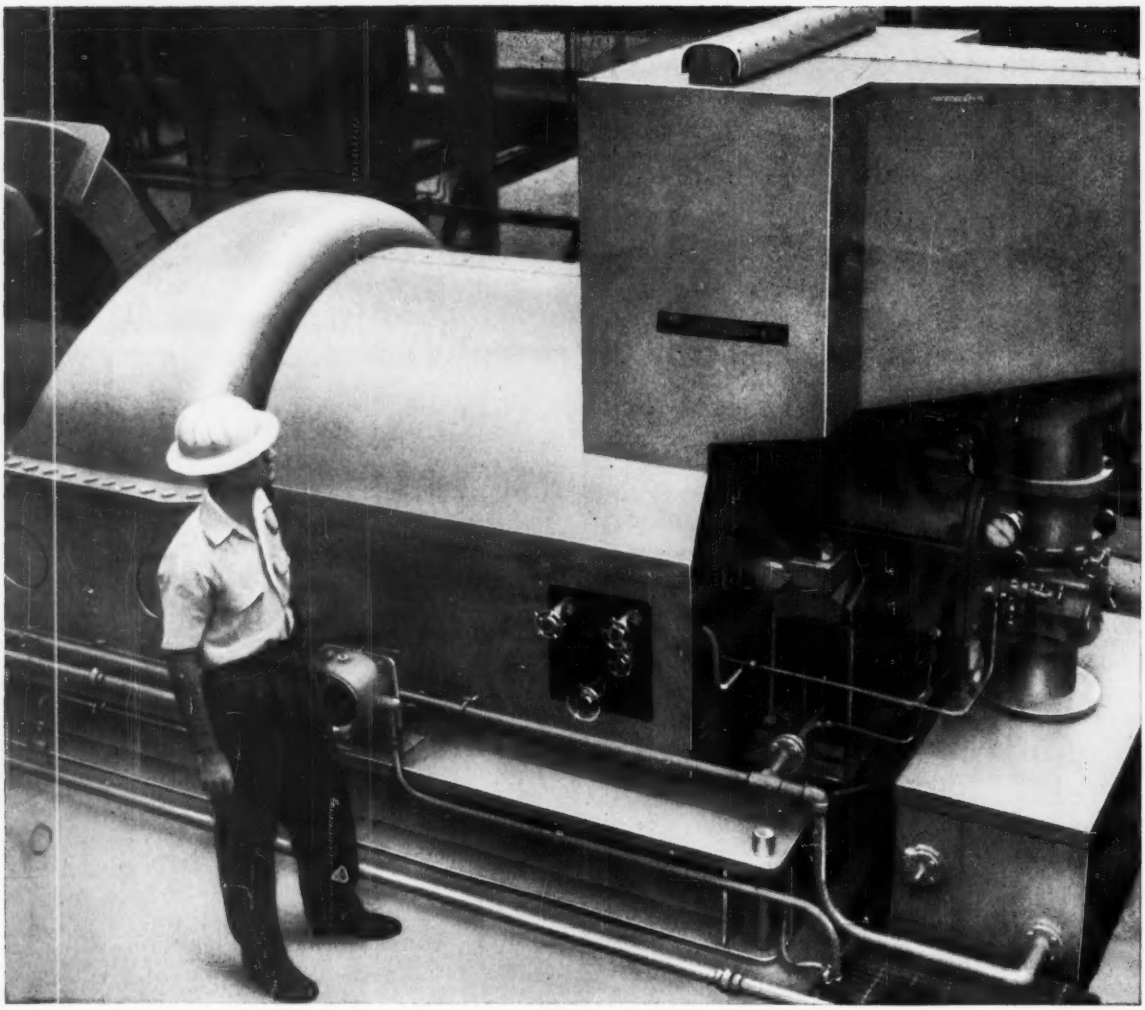


TRADE LESLIE MARK

REGULATORS and CONTROLLERS
Leslie Co., 435-E Grant Ave., Lyndhurst, New Jersey

Over 275 Factory-Trained Engineers At Your Service—Nationwide!

For more facts circle 242 on Reader Service card, p 123



Westinghouse multi-stage, hi-speed turbines guarantee you

...engineered power to meet your exact needs

Why pay for power you can't use? Or, by the same token, why strain a machine beyond its capability? Westinghouse can meet your exact turbine requirements with the world's broadest line of wheel sizes and design capabilities for steam conditions through 2400 psig—1050° F at the throttle, exhausting from 1 in.hg absolute to 300 psig.*

Fitting the right wheel size to the job is the key to efficiency and economy. By knowing your process requirements, cost of steam and number of hours you expect your turbine to run during the "payoff" period, we can provide the turbine design best suited to your power and economic requirements.

To meet these varied requirements, Westinghouse has available five frame sizes of multi-stage, hi-speed turbines with wheel diameters ranging from 12 in. to 32 in. In addition, interchangeability of many wearing parts saves you money on inventories and stocking of spare parts.

Westinghouse turbine specialists located throughout the country are available at all times to provide personal attention to your heat balance problems, and are equipped to offer on-the-spot price and performance data for this entire turbine line. The capabilities of the world's largest and most modern small turbine facility are at your disposal. Call your Westinghouse representative, or write Westinghouse Electric Corporation, Small Turbine Sales, Lester Branch Post Office, Philadelphia 13, Pennsylvania. J-50605

***WESTINGHOUSE MULTI-STAGE, MULTI-VALVE, HI-SPEED TURBINE FRAME CAPABILITIES**

Turbine Frame	M-12	M-16	M-20	M-25	M-32
Number of Stages			As Required		
Wheel Size, in.	12½	16	20	25	32
Maximum hp	4000	5000	7000	10,000	16,000
Maximum rpm	16,000	12,500	10,000	8000	6000
Maximum P_1, psig	1500	1500	1500	1500	1500
Maximum T_1, °FIT	950	950	950	950	950
Maximum P_2, psig	300	300	300	300	50
Exhaust Size, in.	20	24	30	36	48
D. F. Exh. Size, in.	30	36	48	42 x 64½	48 x 84
Max. Inlet Size, in.	5	6	8	10	12

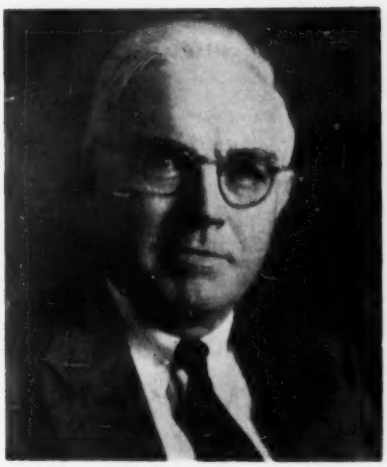
(For special applications, inlet steam conditions to 2400 psig, 1050° F total temperature can be accommodated.)

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

FRED ANNETT 1879-1959



On October 16th, Fred Annett died at Mary Immaculate Hospital, Jamaica, N. Y. He had been Contributing Editor of POWER since he retired in 1951 after 35 years as Associate Editor.

At the time of his 80th birthday on August 26th, Fred had made substantial recovery from an operation performed earlier in the summer and was building strength for further surgery while completing revision of a book. He survived the second operation, but by less than a fortnight.

Despite the knowledge that surgery at Fred's age must always be considered serious, his passing came as a shock to those of us who had worked with him and loved him. Somehow we had pinned hope for a full recovery on the unquenchable vigor and determination with which Fred had surmounted every obstacle in a long and eventful life.

Born near Woodstock, New Brunswick, Canada, Fred Annett won his first job at the age of nine, picking potatoes at 25c a day. When he discovered the farmer wanted him only in the afternoons when the potatoes had dried, Fred decided 12½c a day wasn't enough, and got himself another job where he could work a full day.

In more than 70 years of "full" days since that first job, the initiative, energy and self-reliance Fred revealed then made him, among other things: a master teacher of practical electricity; an acknowledged authority on hydroelectric power, pumping, elevators and mechanical power transmission; an author of enduring technical books; and a "dean" of engineering editors.

Looking back over the long trail that led from the farm through lumber camps and railroad gangs to the work he loved—teaching and that special kind of teaching that is engineering journalism at its best—Fred liked to tell of the friendly guidance and help he got along the way. But the fact is that, more than most men, Fred made his own way. Nothing was handed to him, nothing came easy. And he wouldn't have wanted it any different.

Into everything he did, Fred Annett poured boundless energy and enthusiasm, never let up until he had met his own stern standards. Starting with only the beginnings of a grade-school education, Fred taught himself arithmetic, algebra, geometry. When he had gone as far as he could on his own—and all after a 12-hour-a-day job—he turned to correspondence courses, then an electrical school in New York. And Fred never stopped learning.

During his years as an editor, he successively mastered new technical areas as needs developed and his interests widened. When he was in his 60's, he dug into the developing field of industrial electronics. The result was a study course still remembered by many POWER readers, and another highly successful Annett book.

The determination that marked Fred's lifelong pursuit of learning was typical of everything he did. It made him a great editor and would have won him distinction in any profession. But it was only an outward manifestation of the inner strength of character that made him a man his friends and associates will long remember.

We will remember how ruggedly honest he was with himself, and how he despised any shirking of private or public responsibilities. We will remember that although he had made his own way, or perhaps because of it, Fred never missed an opportunity to offer unobtrusive help to those who were trying to make their own way. We will remember his lifelong interest in young people, and particularly in their education.

Finally, we will remember Fred Annett as a man who found supreme happiness and satisfaction in the vocation we were privileged to share with him.

THOMAS JEFFERSON BUILDING

Electrical services are fed from two 4,000 amp. main distribution boards. Each of the main switch boards is fed by 8-500 MCM conductors per phase.

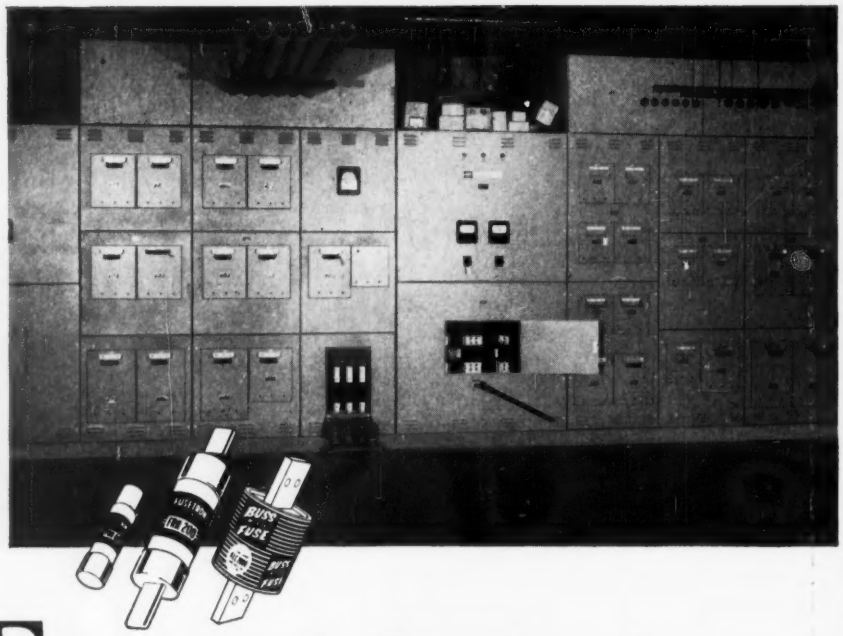
Switch Board #1

Protected by: 3-4000 amp. BUSS Hi-Cap Fuses . . . 12-600 amp., 30-400 amp., 3-200 amp. FUSETRON Fuses.

Switch Board #2

Protected by: 3-4000 amp. BUSS Hi-Cap Fuses . . . 6-600 amp., 33-400 amp., 39-200 amp. FUSETRON Fuses.

All distribution panels protected by FUSETRON dual-element fuses.



Electrical Protection goes MODERN *with* BUSS Fuses

in St. Louis' Newest Multi-Storied Office Building . . .

The Thomas Jefferson Building is another outstanding example of BUSS Hi-Cap and FUSETRON dual-element fuses meeting the requirements for a modern protective device for use in modern electrical systems.

Today's electrical networks, with their tremendous capacities, have emphasized the need for a superior protective device that can be relied on to safely and dependably handle faults of great magnitude.

BUSS Hi-Cap and FUSETRON fuses, because of their high interrupting capacity and life-time dependability have become the natural choice in both new installations and when electrical systems are being modernized.

WHY HIGH-INTERRUPTING CAPACITY AND DEPENDABILITY ARE ESSENTIAL FOR A MODERN PROTECTIVE DEVICE...

CAPACITY

The magnitude of fault current is only limited by the capacity of the transformers or networks. These capacities have been increasing yearly — and most likely will continue to increase.

A modern protective device, therefore, must be capable of interrupting faults of 75,000 to 150,000 ampere which are available today — and be adequately safe to allow for future system growth.

BUSS Hi-Cap and FUSETRON dual-element fuses meet this requirement. The interrupting rating of BUSS Hi-Cap fuses is 200,000 rms symmetrical — and for FUSETRON fuses it is 100,000 rms symmetrical.

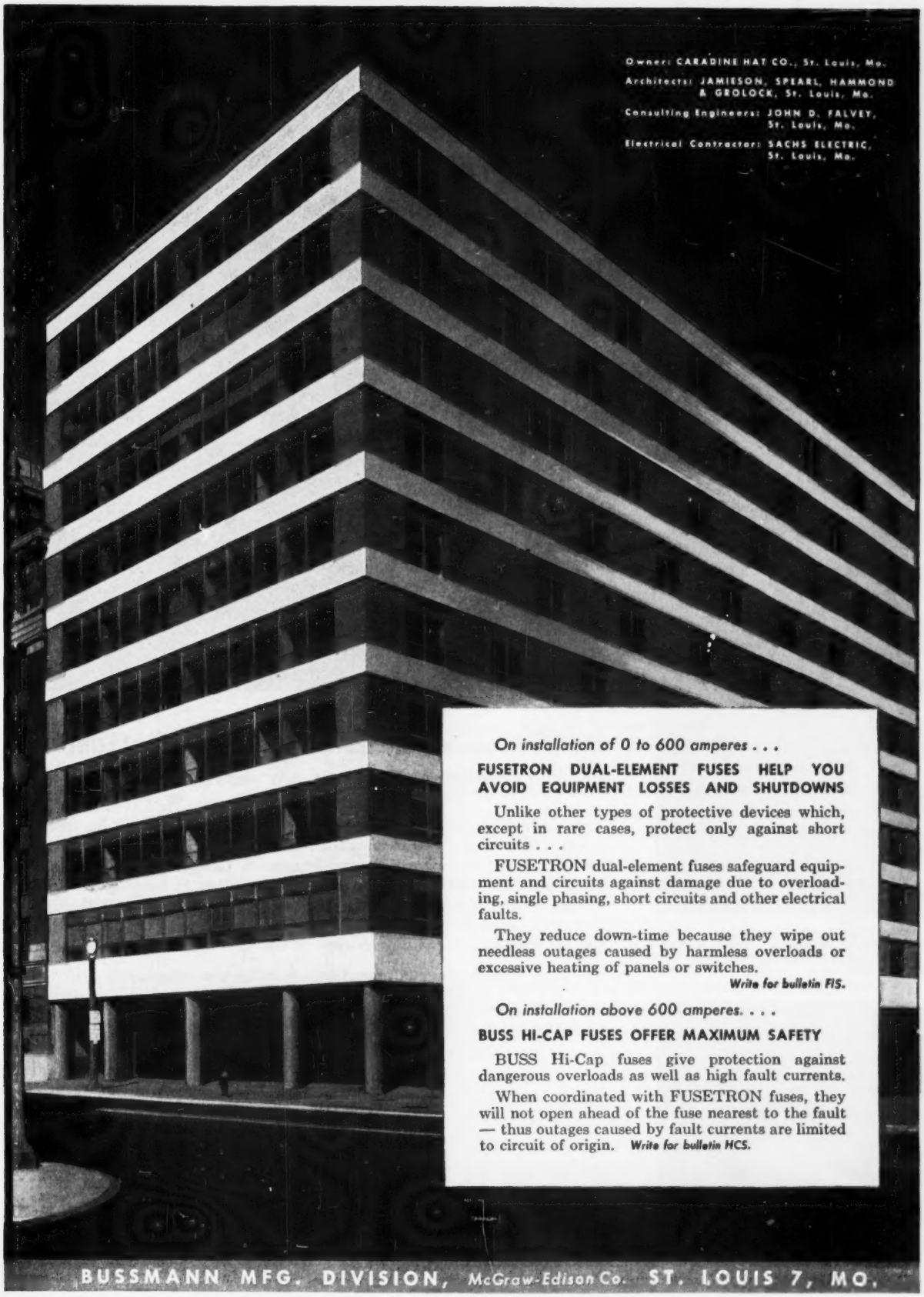
LIFE-TIME DEPENDABILITY

The *Modern* protective device should remain just as safe and accurate through the years as it is on the day installed. Otherwise, how can you be sure it will interrupt these high fault currents should trouble occur 10, 15 or 20 years from now.

This requirement too, is met by BUSS Hi-Cap and FUSETRON fuses — They remain safe and accurate and require no periodic inspection or recalibration, as they have no hinges, pivots, latches or contacts to stick or get out of order.

1159

ANOTHER BUSS HI-CAP AND FUSETRON FUSE INSTALLATION


Owner: CARADINE HAT CO., St. Louis, Mo.
Architects: JAMIESON, SPEARL, HAMMOND & GROLOCK, St. Louis, Mo.
Consulting Engineers: JOHN D. FALVEY, St. Louis, Mo.
Electrical Contractor: SACHS ELECTRIC, St. Louis, Mo.

On installation of 0 to 600 amperes . . .

FUSETRON DUAL-ELEMENT FUSES HELP YOU AVOID EQUIPMENT LOSSES AND SHUTDOWNS

Unlike other types of protective devices which, except in rare cases, protect only against short circuits . . .

FUSETRON dual-element fuses safeguard equipment and circuits against damage due to overloading, single phasing, short circuits and other electrical faults.

They reduce down-time because they wipe out needless outages caused by harmless overloads or excessive heating of panels or switches.

Write for bulletin FIS.

On installation above 600 amperes. . . .

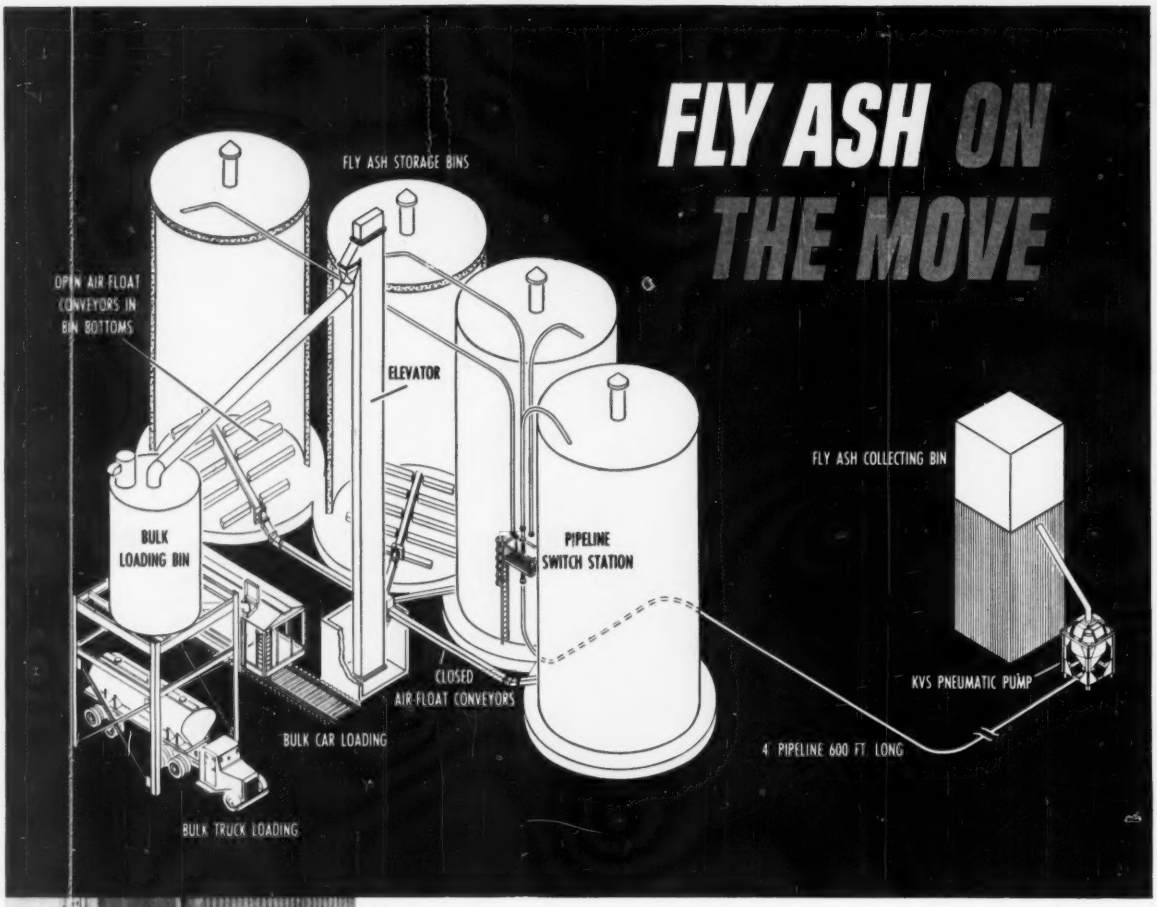
BUSS HI-CAP FUSES OFFER MAXIMUM SAFETY

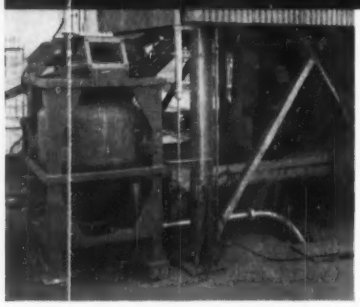
BUSS Hi-Cap fuses give protection against dangerous overloads as well as high fault currents.

When coordinated with FUSETRON fuses, they will not open ahead of the fuse nearest to the fault — thus outages caused by fault currents are limited to circuit of origin. ***Write for bulletin HCS.***

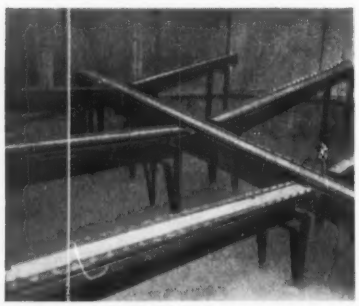
BUSSMANN MFG. DIVISION, *McGraw-Edison Co.* **ST. LOUIS 7, MO.**

For more facts circle 244 on Reader Service card, p 123





From this pump a 4" pipeline carries 25 tons per hour of fly ash some 600 feet to storage! Operation is entirely automatic. A small sample is automatically taken from each 2-ton pump charge.



These Air-Float Conveyors, over the bin bottoms, move the fly ash to the sides and out of the bins to the boot of a bucket elevator. Movement is smooth and positive, even when a bin is loaded with 900 tons of fly ash!

KENNEDY PRESSURE PNEUMATIC CONVEYING SYSTEM AND KENNEDY AIR-FLOAT CONVEYORS PROVIDE THE BEST ANSWER TO THE PROBLEM!

Thousands of tons of fly ash are being used in the concrete mix for three Corps of Engineers' projects along the Ohio and Cumberland Rivers. Every pound is transferred by a KENNEDY Pneumatic Conveying System, from the Louisville Gas and Electric Company Cane Run Power Plant to the storage bins of the Walter N. Handy Company nearby. KENNEDY Air-Float Conveyors do their part too, moving the fly ash from the bins on the first leg of its journey to the job sites.

KENNEDY equipment again proves its versatility and economy!

Contact KENNEDY *for more information on this better pneumatic conveying equipment which is so simple, so economical and so versatile.*

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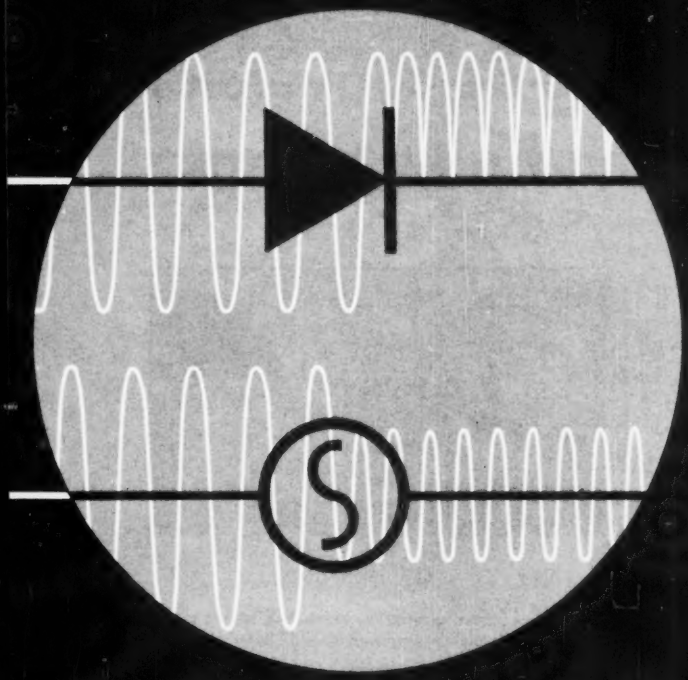


Electrical Conversion

A 24-p report on converting ac to dc and high-cycle ac

By NORMAN PEACH, *Associate Editor*

Use of dc is on the increase. This may surprise those who have relegated the unidirectional currents to a past electrical era. Fact remains that inherent advantages of the dc motor — fine speed control plus favorable torque characteristics — are drawing more converts every day. Couple this with the significant advances being made in conversion equipment, the growing number of industrial demands that cannot be met as effectively, if at all, by ac, and you see more justification for the gradual rebirth of interest in dc. In evaluating the ever-widening dc field, don't overlook the growing needs of industries which are inherently heavy dc users: aluminum, chemical, steel, to name a few. These fields are steadily expanding.

Since practically all today's electric power is generated in 60-cycle form, our dc loads must be fed through converters or rectifiers. Here we find equipment advances being made both with the time-honored rotating machinery and the more-recent semiconductors. The latter, especially silicon, are continually widening their horizons by bidding successfully for ever-larger power-conversion jobs throughout industry.

This interest in dc is not limited to the few areas outlined above. Fuel-cell developments, both here and abroad, open still more new avenues which are inherently dc. Widening interest and concrete achievements in the thermoelectric area pose even broader uses for dc in the years to come.

High-frequency ac is also on a growth curve. Machine tools, hand tools, fluorescent lighting, induction and dielectric heating are some of the high-cycle power applications you must supply. Frequency-conversion equipment used and considered for handling these loads is in this report.

Consider the information in the following 23 pages as a design aid to help you make intelligent decisions in selecting and applying conversion equipment. Use it effectively in planning your plant electrical-system needs.

a **Power** special report
December 1959

Growing demand for ac-dc conversion is being met by old and new means

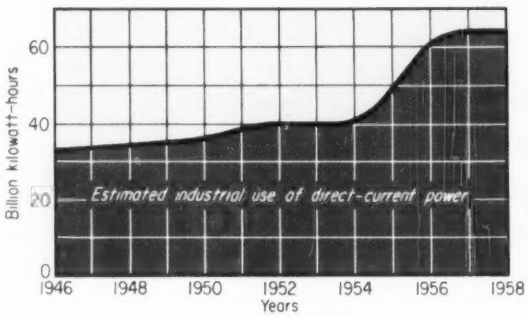
Converters for producing direct current from an alternating-current power source can be classed as (1) rotating machines (2) mercury-arc rectifiers (3) semiconductor rectifiers (4) hot-cathode electron tubes and (5) mechanical rectifiers. Your choice among these will depend on the characteristics of your dc load and the relative cost of the various types of equipment. We describe converters and their behavior in following pages, through p 83. Comparison of converter characteristics and tips on how to pick the right converter for your job are given on pp 84-85.

Rotating ac-dc converters today consist mostly of motor-driven generators, with motor and generator characteristics matched to form a motor-generator set. Generators are designed as though they were driven by a prime mover. Rotary converters, far right, saw wide use before mercury-arc rectifiers were fully developed because the rotary converters were more efficient than motor-generator sets from an overall operating standpoint. There is nothing to recommend them today, since they have many limitations for most applications, but you can still obtain them from at least one manufacturer in the U.S.

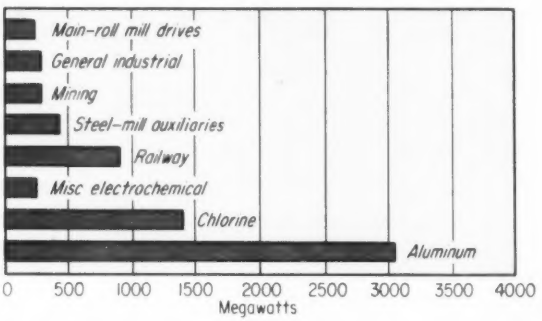
Mercury-arc rectifiers, discussed on pp 79-82, can be classified as *ignitrons, excitrons* and *multianode* types. Latter are no longer made in the United States but are still popular in Europe in water- and air-cooled models.

Semiconductor rectifiers are made from silicon, germanium, selenium and copper oxide. Selenium and copper-oxide units have been around for some time, have been called *metallic* or *dry* rectifiers. Development of silicon has been rapid. It has taken over many high-power rectifying jobs, and has recently eclipsed germanium. With advances of silicon and improvements in selenium these two are likely to dominate the semiconductor field.

Hot-cathode or thermionic electron tubes, discussed on p 83, have their place, especially in high-voltage applications with an "electronics" character. Dc input of high-frequency oscillator, p 88, is one example. *Thyratrons* and *phanatrons* are probably the best-known tubes in this class. Another type is the vacuum diode, now getting competition from silicon cells, but still used for some low-power jobs.



UTILIZATION of direct current has climbed in recent years with increased use of adjustable-speed motors and electrolytic processes



CONVERSION METHODS share the load of industrial direct current in the U.S., installed or on order, in about these proportions

Mechanical rectifiers created interest a few years ago before advent of germanium and silicon rectifiers, but now appear to be fading out of the picture. High efficiency was their advantage, but today silicon with only slightly lower efficiency requires negligible maintenance in comparison. Mechanicals and their behavior are discussed on p 83.

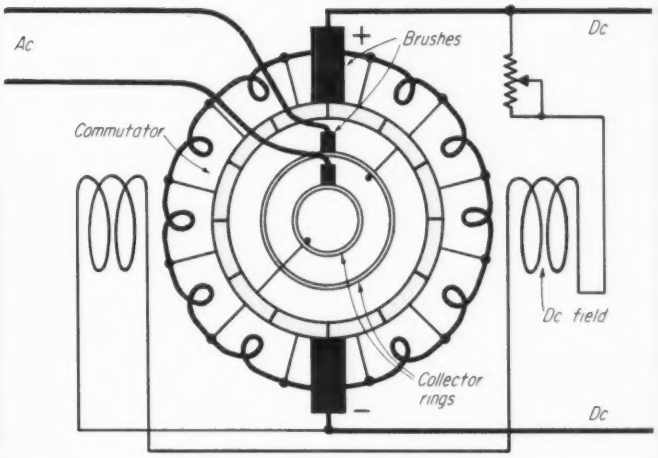
MOTOR-GENERATOR sets still fill a need

Most obvious way to convert alternating current to direct current is with a motor-generator set. The generator can be designed to suit load requirements. While it is probably possible to design a rectifier circuit to take care of any dc load requirements, m-g sets have certain definite advantages for some applications with special needs.

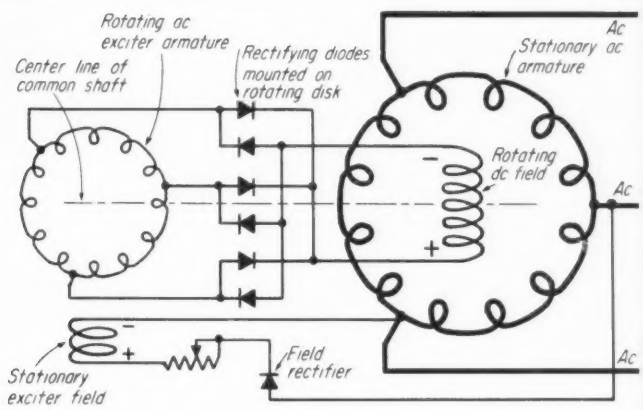
Motor and generator are electrically separate but shaft connected. Surges on generator are transmitted to motor, then to the ac supply. Surges may be damped somewhat by the m-g set's inertia. For some applications a flywheel can be added to the m-g set to store energy to dampen generator load surges, give smoother operation.

Most sets are designed as units, rather than just a motor and generator coupled together. Overall size is reduced, two or three bearings are required instead of four, and alignment problems are simplified in this way.

Rotating converters fit the special applications



CONVERTER-INVERTER machine was formerly popular for ac-to-dc conversion, is now mostly used as dc-to-ac inverter for special applications such as ac control systems operated from batteries. As an *inverter*, machine is operated as a dc motor; the commutator changes dc to ac in winding and ac is tapped off through slip rings. Frequency is dependent on armature speed. As *rotary converter* machine may be accelerated in a number of ways after which it runs off ac lines similar to synchronous motor. Ac is fed to windings through slip rings and is changed to dc by commutator. Dc voltage is fixed by ac supply voltage. Larger units are polyphase, with 6-phase armature connections favored for most applications.



BRUSHLESS GENERATOR was made possible by development of silicon diodes (p 74) rugged enough to stand rotational stress. Diodes are mounted on disk. They pass current in only one direction, and in effect take place of commutator of exciter. Exciter armature, diode disk and main generator field all rotate on the same shaft, eliminating slip rings. Exciter's field is energized with dc obtained from small rectifier. Packaged ac generators of this type are being widely adopted, and an 180-kw brushless exciter is now under development for use with alternators in megawatt sizes. Magnetic amplifiers control field excitation. These brushless generators aren't reversible.

Adjustable-speed dc motors, as met in large heavy-duty applications, may often be supplied to advantage by m-g sets. Dc terminal voltage is readily adjustable by generator field control. Armature control of the motor driving load is accomplished without an armature-circuit rheostat (the Ward-Leonard system). Complicated speed-control systems such as found in steel and paper mills often employ booster generators. Booster armature is hooked up in series with the armature of an individual dc-drive motor.

Regeneration is a natural advantage of m-g sets, and suitable controls for regeneration are normally simple. Dynamic braking and return of power to the ac lines can be accomplished when load overhauls the dc-drive motor, forcing it to act as a generator. Motor and generator of the m-g set in turn reverse their functions.

Low voltage with accurate voltage control is required by some plating processes, of which large-scale tin- and chrome-plating lines are typical. Voltages in this classification range between 1 and 50 v, and current can be 3000 amp or more. Such processes have in general depended on m-g sets, but rectifier equipment has moved into this field as control methods for rectifier systems improve.

A few very special applications requiring enormous currents make use of homopolar generators. One such generator delivering 150,000 amp at 7.5 v for resistance welding of large-diameter steel pipe was described in POWER, March 1956, p 136.

Power factor of the ac supply can be improved if a synchronous motor with leading power factor is used to drive the motor-generator set.

RECTIFIER CIRCUITRY hinges on "quality"

Rectifiers are made up of *rectifier elements* combined in suitable circuits. A rectifier can be thought of as an electrical check valve, a device which readily passes current in one direction but blocks flow when voltage is applied across it in the opposite direction. However, a small leakage current may flow in reverse direction. Symbol for the element in schematic diagrams is a solid arrowhead pointed at a bar. Current flow is from arrowhead to bar.

Actual rectifier elements may be as different as silicon crystals and contacts of mechanical rectifiers. To explain basic principles let's consider that all rectifier elements perform in the same manner.

Single element in an ac circuit permits only the positive half-cycles of the ac sine wave to pass; that is, element conducts when voltage across it is + to — . Such an arrangement is called a half-wave rectifier. During negative half-cycle, when voltage across element is — to + , the element doesn't conduct. Output voltage across the load is *unidirectional*, but is not continuous, as shown at top right. With a resistive load the current wave has same form as voltage wave.

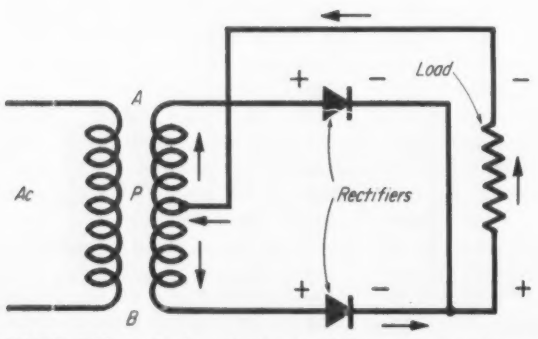
Full-wave rectification can be obtained from a single-phase source if two rectifier elements are set up so that one conducts during the positive half-cycle and the other during negative half-cycle. Center-tap circuit, below, has an input transformer with a tap at mid-point of its secondary, *P*. When voltage induced in secondary is from *A* to *B*, current will flow through half of the secondary from *P* to *B*, through the rectifier element (+ to —), through the load and back to point *P*. When voltage across secondary reverses during the next input half-cycle, current will flow from *P* to *A*, through other element (+ to —), through load in same direction as before, and back to *P*. This procedure is repeated every cycle of the ac supply. Output curve is at center, right.

Bridge circuit also produces full-wave rectification. In circuit below, when ac voltage is + at *A* and — at *B*, current flows from *A* to *D*, through load, then from *C* to *B*, passing through two elements. When supply voltage is — at *A* and + at *B*, current flow is *B* to *D*, load, *C* to *A*. Bridge circuit requires four elements instead of two, but has some advantages. Input transformer may not be needed if ac and dc voltages are satisfactory; if used it is more efficient than in center-tap scheme since all the winding is operating at same time. For same output voltage, bridge elements need block only half the reverse voltage center-tap elements must withstand. Reason: elements in both these circuits must block voltage *A-B*, but *A-B* for bridge equals *A-P* for center-tap circuit. Higher voltage is practical.

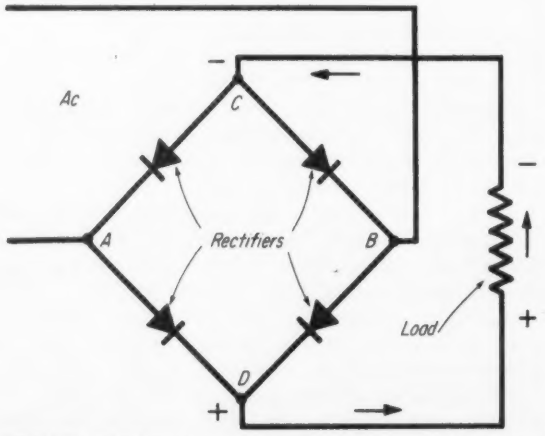
Power rectifiers are generally 3-phase. Simplest 3-phase circuit is wye with neutral tap, shown on facing page. One element conducts at a time — the one with greatest positive voltage across it (process by which conduction passes from element to element is called *commutation*). One obvious advantage of a 3-phase rectifier is that output voltage never goes below a certain value while voltage of full-wave single-phase rectifier pulsates between a peak value and zero. More complicated circuits for 3-phase input, p 72, have output waves closely approximating true direct current. Variation of output voltage from a constant dc value is known as *ripple*.

Ripple may be thought of as an ac component superimposed on a constant dc component. In some respects this ac component behaves like real alternating current. *Ripple factor* is ratio of rms value of the alternating component to the dc value of the wave. Rectifier circuit with a high ripple factor doesn't come as close to producing true dc as one with a low factor.

Compare single-phase bridge (ripple factor equals 0.48) with 3-phase bridge described on p 72 where ripple factor equals 0.04. Notice the ripple has a frequency which is some multiple of ac-input frequency.



CENTER-TAP single-phase circuit gives full-wave output using two rectifying elements: one passes current while the other blocks it



BRIDGE single-phase circuit requires four elements but input transformer isn't essential. Two elements are in series when conducting

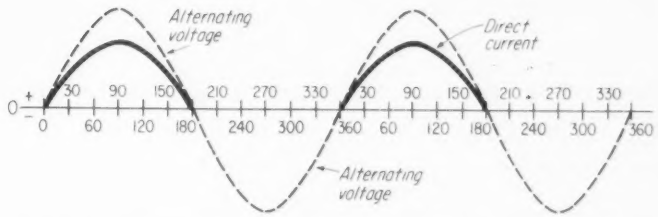
of dc required

Blocking occurs every negative half-cycle. Maximum voltage across element in reverse direction is peak voltage of the ac wave, called *peak inverse voltage* (piv). Piv is often the decisive factor in choosing a particular kind of rectifier element, which must be able to block piv without failure under any service conditions.

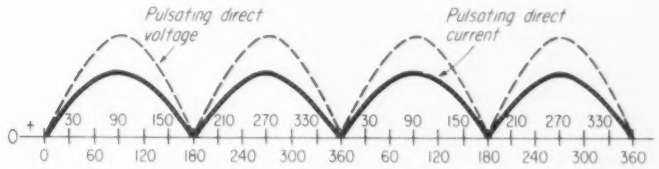
Resistance to forward current exists to some extent in all rectifier elements, resulting in voltage drop, power loss and heating. Similarly, no rectifier perfectly blocks reverse current. So reverse leakage current also contributes to power loss and heating. These forward and reverse losses are different for different element types. *Efficiency* is ratio of total output power to input power. *Conversion efficiency* is ratio of dc-output power to input power; ac-output component is considered as loss. If large, this can cause heating in dc motors because of induced eddy currents and hysteresis in motor's metallic parts. Conversion efficiency is affected by the ripple.

Utility factor, otherwise called *utilization factor*, is ratio of the dc-power output, kw, to ac input to transformer, kva. It's a way of expressing how effectively the circuit utilizes the transformer. Notice in table on p 72 that the 3-phase-bridge and double-wye circuits utilize transformer capacity advantageously.

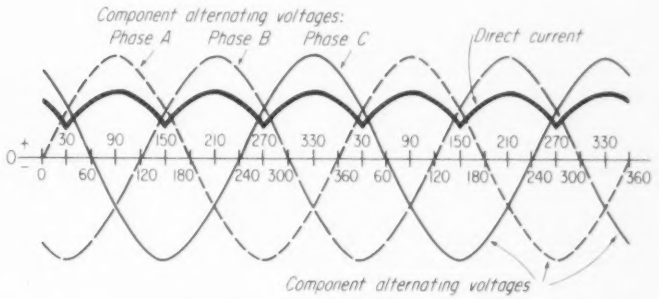
Positive half-cycles form dc output wave



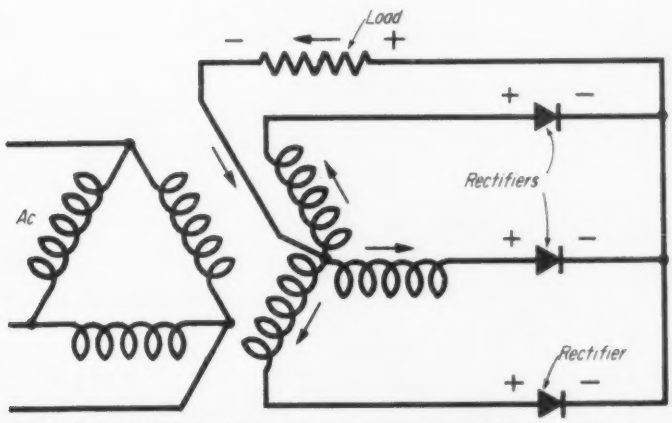
HALF-WAVE rectification is produced when single rectifier element is connected in series with single-phase circuit. Negative half-cycles give no output voltage



FULL-WAVE rectification results when two rectifier elements are combined in a single-phase circuit using either of circuit arrangements shown on facing page


Component alternating voltages:
Phase A
Phase B
Phase C
Direct current
0 30 90 150 210 270 330 30 90 150 210 270 330
0 60 120 180 240 300 360 60 120 180 240 300 360
Component alternating voltages

THREE-PHASE unit uses three rectifier elements. Output of unit is smoothest of the three types, since the circuit combines three half-wave single-phase waves



THREE-PHASE WYE is simplest of several circuits operable from 3-phase ac supply. Each element conducts in succession while remaining two are blocking

Rectifier circuit is arranged to produce desired output wave shape and best utilize characteristics of rectifier elements

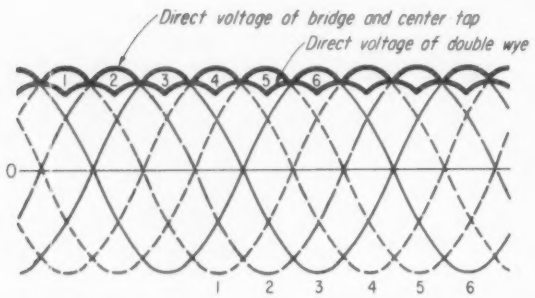
Many variations possible with 3-phase inputs

Many kinds of rectifier circuits supplied from 3-phase power are used. Circuits for 2-phase input are also possible but are rarely found in practice. You may find circuit terminology confusing since a given circuit is not always called by the same name. The three circuits below are in common use; the bridge circuit is most favored today for semiconductor rectifiers and the double wye for mercury-arc units.

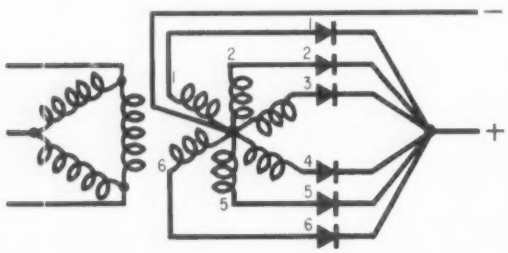
The 3-phase center tap develops 6-phase from a 3-phase supply. Transformer windings are arranged with respect to the neutral center tap, sketch below, so each of three input phases is split into two components 180 deg apart. Each of six elements conducts in turn for 1/6 cycle. If point *1* is at maximum positive voltage with respect to neutral, current flows through branch *1*, the load, and back to neutral. As voltage of *2* increases, voltage of *1* decreases; at equal voltage current begins to flow in *2*. When voltage at *2* is greater, current stops in branch *1*. This highly efficient circuit is sometimes used in low-voltage large-scale electrochemical processes.

The 3-phase bridge, sometimes called a 2-way circuit, has two elements connected in each 3-phase branch, as sketched below. When branch *A* is positive with respect to branch *C*, current flows through element *1*, the load, element *6* and branch *C*. As branch *B* becomes more positive than branch *A*, current flows through element *2*, load, element *6* and branch *C*. When *B* becomes more positive with respect to *A*, current flows through element *2*, load, element *4* and branch *A*. Conduction sequence in rectifier elements is; *1-6*, *2-6*, *2-4*, *3-4*, *3-5*, *1-5*. Resultant wave has six peaks per cycle and resembles the 6-phase output. Bridge arrangement is favored for higher dc voltages.

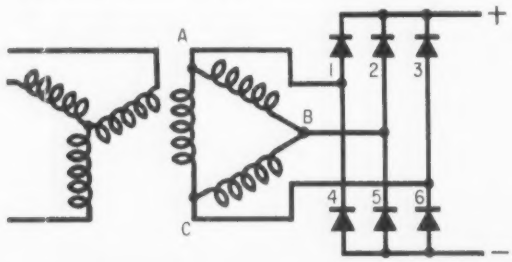
The 3-phase double wye resembles 3-phase center-tap circuit but has an *interphase transformer* connected between the two neutrals, sketch below. When branch *1* has maximum positive voltage with respect to N_1, current flows through element *1*, the



RESULTANT of full-wave 3-phase or 6-phase components has a low ripple factor and is sufficiently flat for most purposes



CENTER-TAP 3-phase circuit is effectively a 6-phase circuit, often called *6-phase star*. Current flows in transformer neutral

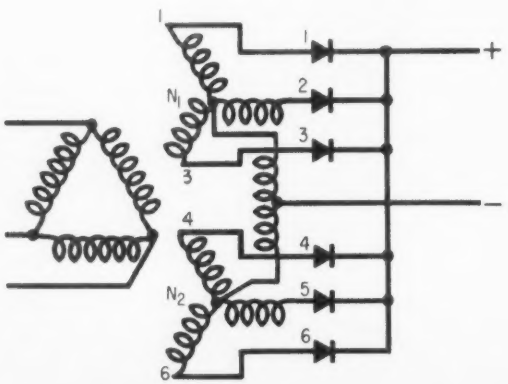


3-PHASE BRIDGE is full-wave (2-way) in character, gives flat, low-ripple resultant similar to that of 6-phase circuits

High-power circuits have three, six or more phases

Characteristics of circuits

Circuit	Conversion efficiency, %	E_{ac}/E_{dc}	Ripple factor	Piv = E_{ac} x	Avg util factor
Single phase					
Half wave	40.6	2.22	1.21	1.414	0.286
Center tap	57.5	2.22	0.48	1.414	0.670
Bridge	81.2	1.11	0.48	1.414	0.813
Three phase					
Single wye	97.0	1.48	0.21	1.414	0.662
Center tap	99.5	1.38	0.04	1.510	0.650
Bridge	99.5	0.74	0.04	1.414	0.955
Double wye	99.5	1.48	0.04	1.414	0.787

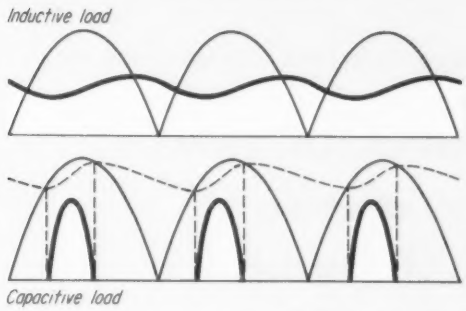


DOUBLE-WYE is used frequently. An interphase transformer tends to improve performance during commutation

load, upper half of interphase transformer and back to N_1. But when current flows through half the transformer, current must flow in the other half so sum of ampere-turns equals zero. Thus element *4* also conducts, having greatest positive voltage in its branch. As voltage in branch *1* decreases and increases in *4*, *1* and *4* become equal. Commutation to *4* can't occur immediately, however, because of the interphase transformer. Current can't stop flowing through element *1* until element *2* begins to conduct. The conduction period is twice that of 3-phase center-tap circuit. Double wye is favored for lower dc voltages.

Load reactance affects current wave shape, above. High inductance such as dc-motor field makes high-ripple voltage acceptable. Capacitive load charges until it reaches a critical value, acting as a counter emf. Current flows in the load only during intervals when voltage peaks exceed the value of the sustained-charge voltage. Current therefore flows in separate pulses. Similar condition exists with a counter-emf load such as a storage battery. Sustained charge in this case is the battery voltage, which increases as battery charges. Battery conducts when applied voltage is above this level.

Nature of load affects dc output



REACTANCE distorts sine wave. Inductive load tends to smooth it while current to capacitive load occurs as pulses

Some rectifiers are designed to control the dc output

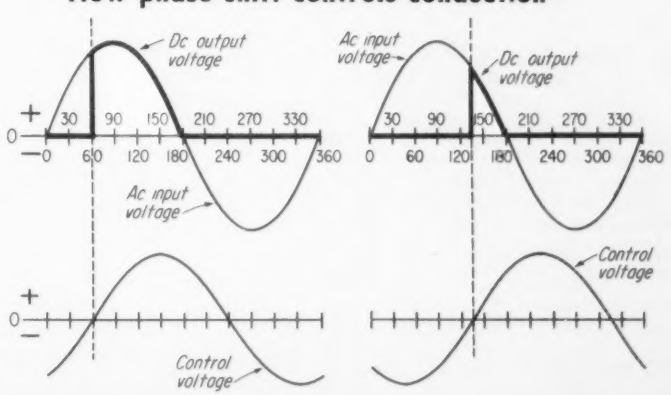
Mercury-arc rectifiers, gas triodes and the more recent silicon controlled rectifiers do not conduct until they are *fired* or triggered by control voltage applied to a third terminal. So point on sine wave at which rectifier element conducts is controllable. Output is composed of portions of a half-cycle instead of complete half-cycles. This affects rms values of voltage, current and power in output. These latter quantities can be adjusted or modulated by changing the angle at which rectifier fires. If firing angle is advanced beyond 90 deg, peak values can also be reduced.

Once one of these rectifiers has been fired it continues to conduct until the sine wave reaches zero and blocking action begins. So the firing voltage need not be sustained during conduction. One commonly used firing method uses positive phase shift, sketch right. Firing circuit (see p 81) is supplied from same source as rectifier, but phase shifting displaces control sine wave by desired number of degrees. Control signal is continuously on the firing terminal of rectifier, but nothing happens until control voltage begins to increase in positive direction. At this point conduction occurs and continues throughout remainder of the positive half-cycle of voltage.

Examples of positive-phase-shift firing are illustrated below for firing angles of 60 and 135 deg. Remember that there are other methods of getting a firing signal. One is by magnitude of a direct voltage superimposed on an alternating voltage. The direct voltage opposes the positive half-cycle of the alternating voltage. Then by varying magnitude of the direct voltage you can alter the angle at which positive control voltage will appear.

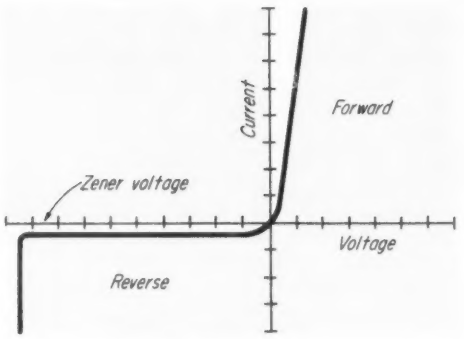
Phase shift is most simply obtained by circuits combining inductance and resistance or capacitance and resistance in appropriate proportions, p 81. Sometimes a more satisfactory method uses a device with polyphase stator and single-phase rotor. When the stator is supplied with polyphase current and the rotor is prevented from turning, phase angle of the induced voltage in the rotor with respect to stator voltage changes with the position of the rotor. Adjustable-phase voltage is obtained by mechanical shift of rotor position. This method is usually more expensive.

How phase shift controls conduction



CONDUCTION occurs when rectifier is triggered by positive control voltage. Angle at which control voltage goes positive can be adjusted by shifting its phase

SEMICONDUCTOR elements rectify by electron transfer at junctions



TYPICAL SEMICONDUCTOR'S forward, reverse characteristics give it an almost ideal rectification curve

Semiconductors are solid substances which permit current flow in one direction and block current flow (except for small reverse current) in other direction. This is accomplished by internal behavior of their electrons and atoms and not by any obvious mechanism such as anode-to-cathode discharge (p 79). Actually, a semiconductor rectifier element is a composite substance: a *junction* or barrier between two different substances.

In order to better understand advantages and limitations of semiconductor rectifiers, let's take a look at explanation which physicists offer today for internal behavior of these devices. Most research has been done on crystalline semiconductors such as silicon and germanium. Characteristics of selenium and copper oxide are well known from experience in their application and performance, but how they behave inside to accomplish rectification is less clearly understood.

For sake of simplicity, let's consider a hypothetical semiconductor with crystalline structure resembling germanium, shown on opposite page. This substance is produced in extremely pure form; some impurities can be detected readily in concentrations as minute as one part in 10^{11}.

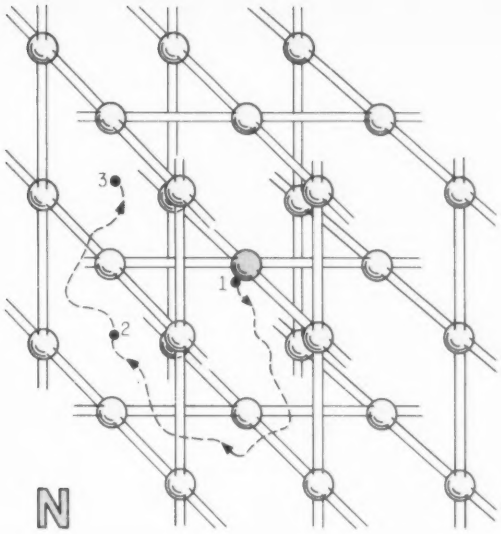
Structure of our hypothetical crystal is such that each atom normally has eight covalent bonds, shown by lines in sketch, right. Pairs of bonds connect adjacent atoms. From chemistry you'll remember that covalent electron bonds are one type of force binding atoms together to form molecules, in this case a crystal lattice. To produce eight covalent bonds an atom must have *four* valence electrons—electrons which share in the bonds. Now if an atom of another element with *five* valence electrons is inserted in place of a normal atom there is an extra electron which can't participate in any of the bonds. Such electrons are held to their atoms by relatively weak forces and tend to drift off among the atoms, shown in a number of positions *1*, *2*, *3* in sketch *N*. By controlling the number of atoms with an extra electron (donor impurities), number of free electrons can be prescribed. Crystals with free electrons are called *negative*, or N crystals.

Positive, or P, crystals can be made by adding to the originally pure structure atoms having *three* valence electrons, that is, one less than the four required to form normal covalent bonds. This lack of one electron in an atom, or "empty place," is called a *hole*. An atom with a hole (*1* in sketch *P*) exerts a strong force to fill it, and may cause an electron from an adjacent atom to jump over into the hole. The hole is now transferred to atom *2*. This process is repeated, and the hole

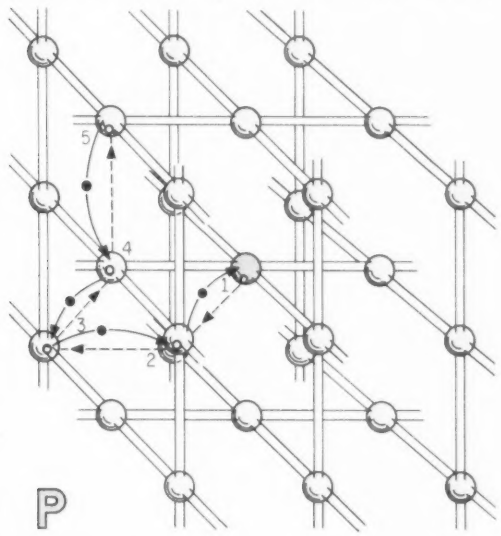
Here's how semiconductors compare

	Silicon	Germanium	Selenium	Copper oxide
Size	Very small	Very small	Large	Large
Weight	Very light	Very light	Light	Heavy
Cooling	Natural or forced	Natural or forced	Natural or forced	Natural or forced
Life	Very long	Very long	60,000-100,000 hr (convection-cooled ratings)	Long-proven
Aging (forward resistance)	None	None	Increases	Stabilizes
Forward loss at same current density	Good	Excellent (lowest)	Fair (highest)	Good
Leakage (reverse current)	Excellent	Excellent	Good	Fair
Ability to heal	None	None	Excellent	Good
Unforming	None	None	Appreciable (low-temp process)	None
Series operation of cells	Good	Good	Excellent	Excellent
Parallel operation of cells	Good	Good	Excellent	Excellent
Cell-operating temperature limit	250 C	85 C	85 C	75 C
Thermal capacity	Poor	Poor to good	Fair	Best
Humidity effects	Hermetically sealed	Hermetically sealed	Negligible	Negligible
Frequency response	Good	Good	Poor	Fair

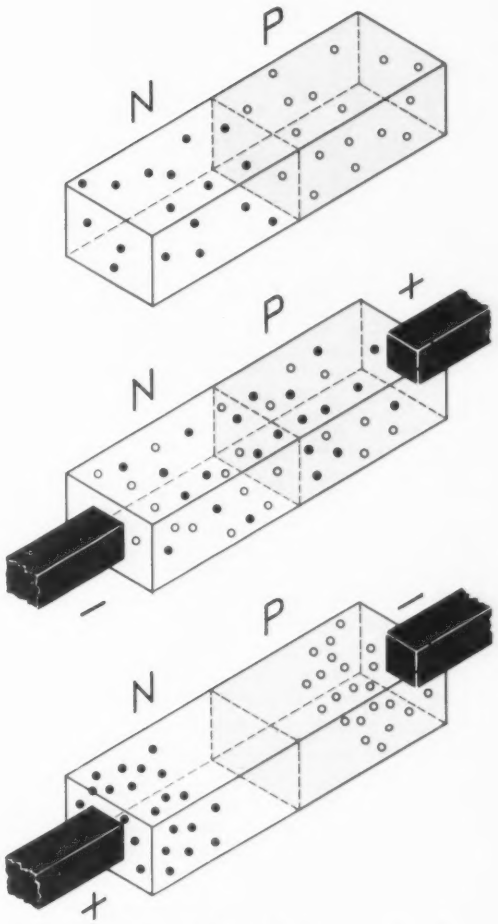
Semiconductor action depends on internal electron behavior



N TYPE crystal has extra electrons contributed by impurity atom. These wander freely in lattice; number can be fixed



P TYPE crystal has impurity atom with electron deficit or *hole*. Hole is exchanged by atoms; electrons jump to fill it



JUNCTION of N and P crystals forms rectifier. Proper polarity makes electrons and holes migrate so current flows

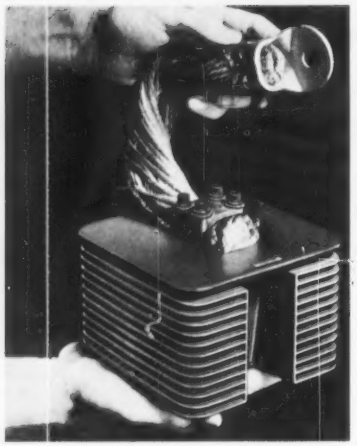
is said to travel from *1*, *2*, *3*, *4*, *5*, etc, although actual movement is by separate electrons jumping from *2* to *1*, *3* to *2*. Atoms which are added to create holes are *acceptor impurities*.

Junctions of N and P crystals are formed by various processes to make rectifier elements. Region of the junction may be thought of as a barrier. Without applied voltage a few electrons and holes will cross the barrier but will cancel each other out. Now if voltage is applied across the junction so that P is + and N is —, electrons will be attracted from N to P and holes will be attracted from P to N. Holes will be filled with electrons arriving at the — terminal. Conduction therefore takes place through the junction, and current flows in the circuit.

Blocking occurs when polarity of applied voltage is reversed. Electrons are attracted away from the barrier toward the + terminal and holes are attracted to the — terminal. There is no exchange of electrons or holes between N and P, and therefore the rectifier doesn't conduct. At a certain value of reverse voltage, called *Zener* voltage, electrons are forced through junction from the external circuit as in an ordinary conductor. Junction isn't damaged unless current is excessively high. Current is limited by load or series impedance. In power applications it's desirable to keep series impedance low; the semiconductor cells are usually ruined if peak inverse voltage is permitted to exceed the Zener voltage.

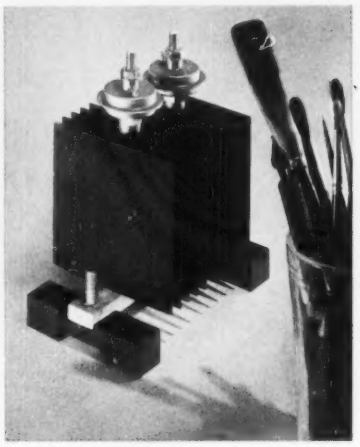
Conduction in the Zener region is used in certain special applications as, for example, the silicon-controlled rectifier described on p 77, and in some static control devices.

Typical cells designed for air or liquid cooling



AIR-COOLED GERMANIUM cell is mounted integral with heat sink for high current

LIQUID-COOLED GERMANIUM rectifiers have heat sinks for a circulating coolant



AIR-COOLED SILICON cells may be mounted on individual radiators; assemble easily

Semiconductors are grouped for high power output

Semiconductor elements, or *cells*, consist of rectifying junction with terminals connected to the junction and provision for removing heat, plus a "package" to give cell mechanical strength and exclude contaminants. Germanium and silicon cells are similar in construction. Selenium and copper-oxide cells are alike in some ways but quite different from silicon and germanium. Let's first consider germanium and silicon.

Junctions in both silicon and germanium cells are thin wafers — up to ¾ in. in diameter and a few thousandths of an in. thick. Wafers are soldered to metal terminals, usually copper or aluminum. One terminal is generally a stud connection to a heat sink or part of heat sink itself. Other terminal normally includes a pigtail.

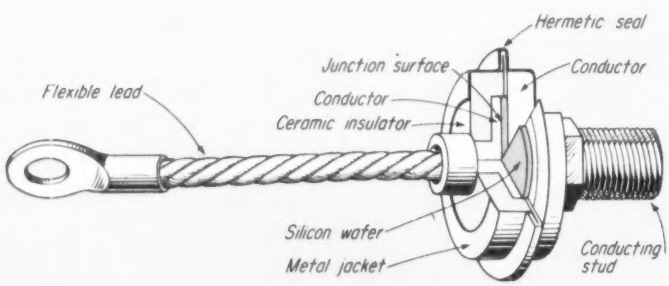
When germanium and silicon cells were first produced a few years ago they often failed or degraded because contaminants affected the junction. Hermetic sealing solved this problem. Plastic, ceramic or other insulating compounds seal the junction and are held rigid by a metal jacket. Mechanically rugged, these cells withstand vibration, can be operated in any position, even rotated at high speed as in generator on p 69.

Size of cell, exclusive of heat-removing mechanism, is small compared with other rectifier elements of same power rating. A stud-mounted silicon cell, similar to one below and rated 85-amp dc, is only about 1⅝ in. in diameter and 4⅔ in. long including pigtail. Each cell, however, requires a certain volume of heat-removing equipment which must be considered when comparing rectifier volumes.

Cooling in some form is essential, and effectiveness of heat sink is important factor in cell rating (see POWER, April 1959, pp 82-85). Power losses in cell are concentrated in the small junction wafer. Junction normally operates at a given temperature rise above ambient, see table of properties, p 74. Overload causes excessive power loss, quickly raising junction temperature. Current overload capacity is generally low because cooling system can't remove heat from junction fast enough. Overload capacity is obtained by derating continuous ratings of the cells.

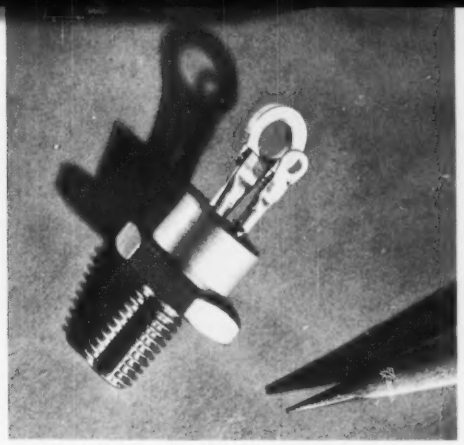
Cooling is accomplished by mounting cells on a block of copper or aluminum serving as a heat sink. Latter may have fins for air cooling (either natural radiation or forced air) or internal channels for liquid cooling. Individual heat sinks may be used, or cells may be mounted on a single liquid-cooled bus, see p 85.

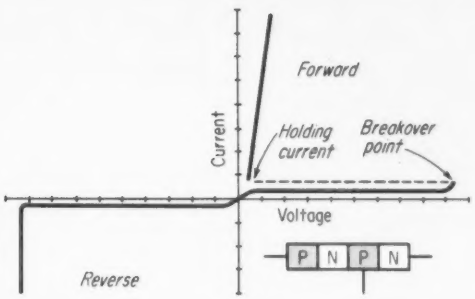
Life expectancy of a hermetically sealed silicon or germanium cell has not been established; present evidence indicates it's unlimited. They don't



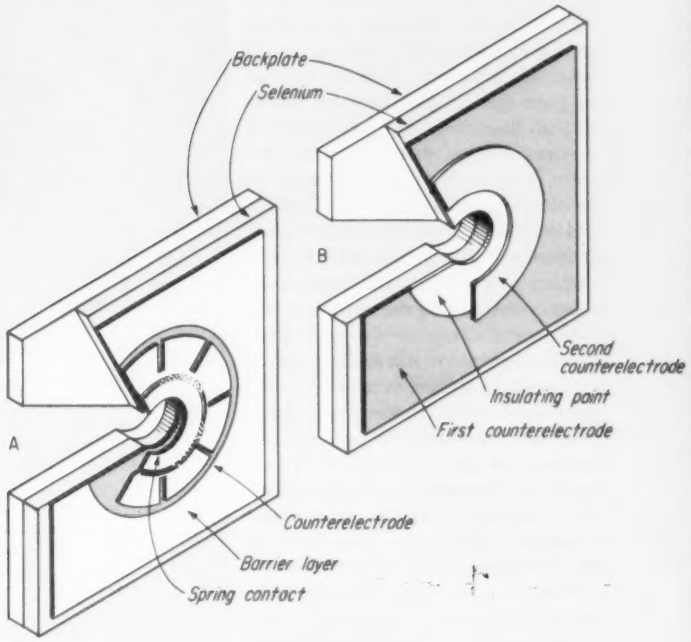
SILICON CELL consists of thin wafer of P-N junction between metal terminals. Cell is hermetically sealed to exclude contaminants, keep characteristics stable

Selenium cells have built-in cooling plate





SILICON CONTROLLED RECTIFIER has third terminal called a *gate* for signal to initiate its conduction



SELENIUM cells are built up on a plate; metal disk (counterelectrode) forms other terminal. Cells mounted in stacks make up units

age, that is, increase in forward voltage drop; neither do they unform. *Forming* is a process in cell manufacture in which cells are loaded to certain values to orient and stabilize their characteristics. Cells that don't unform are suited to applications where they may stand unused for long periods yet must be ready to function when called upon. Typical application is supplying dc to circuit-breaker coils.

Voltage rating of cell depends on several complicating factors. Most important is that peak rating can't be exceeded. Even short-duration voltage surges, which may be unsuspected on a I-v line, can ruin a cell. Voltage that can be sustained is partly dependent on junction temperature and current conducted during previous half-cycle.

Failure of silicon and germanium cells is in form of a short-circuit rather than open circuit. They're "all or nothing" devices; unlike selenium and copper oxide they don't *heal*, that is, a small breakdown doesn't burn itself clear. Instead it almost immediately ruins the cell. In today's rectifier equipment, however, provision is made so that failure of a few cells doesn't seriously affect overall performance. Defective cells can be replaced without difficulty. In some designs it is possible simply to exchange a drawer without shutting down operation of rectifier.

Protection of rectifiers from failure of individual cells is accomplished by fuses, usually the current-limiting type. Each cell may have an individual fuse, or a fuse may protect a group of cells. Because of their extremely low forward drop, these rectifiers can produce heavy short-circuit currents. If current-limiting fuses aren't used, series impedance may be advisable.

Grouping cells in series and parallel is necessary to get required voltage and current ratings. Maximum allowable piv for silicon cells is around 500 v, germanium allowance is about 150 v. Research on silicon promises higher piv ratings. Characteristics of cells are not identical, though manufacturers may carefully test and sort cells in order to match them. Operation of cells in series is common practice. If reverse resistances aren't closely matched, external resistors must be employed to insure proper division of voltage across cells.

To get large rectifier output (10,000 amp units have been built) cells are paralleled. Forward characteristics of cells must be matched for equal current division. Current-balancing reactors can be used and will help compensate for unmatched cells.

Controlled conduction of semiconductor rectifiers was not possible until development of the silicon-controlled rectifier. With all other semiconductor rectifiers, voltage regulation or variation on the dc side must be handled on the input side. This involves manipulating the input power circuit as, for example, by a load-tap-changing transformer. Controlled silicon rectifiers are at present available only in small sizes (16 amp, 400 v), but 50-amp, 200-v units are under development, and it's reasonable to expect larger sizes in the near future.

Cell is composed of a series of junc-

tions, P-N-P-N, as shown on p 77. A third terminal, called the *gate*, is attached to the inside P section (small terminal in photo). With no voltage on gate, the P-N-P-N junction blocks in both directions. But with sufficient forward voltage, cell reaches its *forward* Zener region and nondestructive breakdown occurs. Cell follows its normal conduction characteristics for remainder of positive half-cycle, continuing to conduct even though forward voltage is reduced below the breakover (Zener) voltage. It then blocks current in reverse direction.

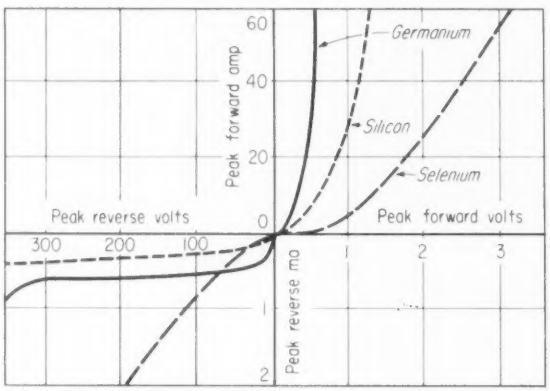
If a small voltage is applied to the gate when cell is blocking in forward direction, the breakover can be made to occur at operating voltages safely below the forward Zener voltage. Thus it is possible to control the firing angle at which conduction occurs and modulate output as described on p 73.

Selenium cells are differently constructed from cells previously discussed; two typical constructions are shown, p 77. Both cells have an aluminum backplate serving as a terminal to the selenium layer, while supporting it and radiating its heat. Methods of applying selenium vary. Cell type *B*, above, has selenium applied by evaporation in vacuum. This improves crystal formation leading to more desirable characteristics, especially regarding current density and aging. In type *A*, a nonmetallic barrier layer is added to improve piv characteristics. Counterelectrode is usually a low-melting-point alloy containing cadmium. Cells such as these are stacked on insulating tubes in combination with insulating washers and metal washers for terminals.

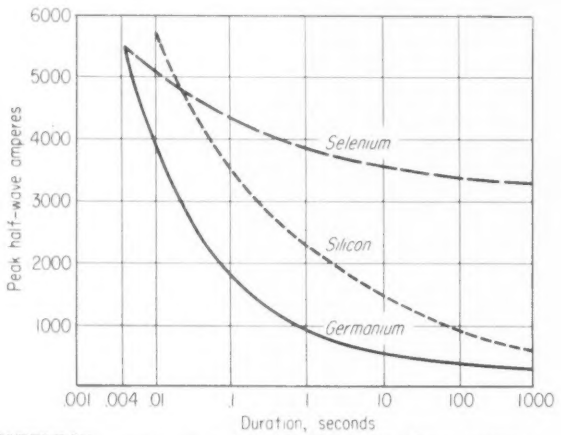
Selenium rectifiers are simpler and less expensive than silicon or germanium. They can stand rough electrical treatment — overloads, voltage surges, etc. They heal, but they age and tend to unform. "Death" has been arbitrarily fixed at 100% increase in forward resistance, although for many applications this is not the end of useful life. New type cells have life expectancy of 100,000 hr. Available today are cells rated 73-v piv or 52-v rms. Usual NEMA current density is 160 ma per sq in. Temperature ratings in some cases run as high as 85 C.

Copper-oxide rectifiers were the first semiconductors developed. In construction they are simple. A copper disk is oxidized on one side with a thin layer of Cu_2O next to the copper, equivalent to a semiconductor junction. Compared with selenium they are heavy, have lower forward current density and higher reverse leakage. But they don't unform, and aging stabilizes after a break-in period. They were widely used for instruments and relays before silicon cells were developed and took over this field.

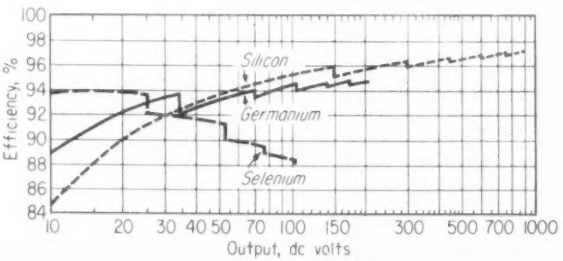
Other semiconductors are being developed for applications outside of the power field. Some of these may turn out to have characteristics recommending them for future power rectifiers. New semiconductors considered are compounds rather than elements; among them are gallium antimonide and indium arsenide. Compound semiconductors are discussed in AIEE paper No. 57-1046, *III-V compound rectifiers*, by G B Kich.



FORWARD-REVERSE characteristics of typical semiconductor cells indicate suitability of each to different voltage-current ratios



OVERLOAD capacity of typical individual cells shows susceptibility of silicon, germanium. Cells are derated for particular jobs



EFFICIENCY of germanium and silicon is highest toward upper voltage range while selenium falls off; selenium is not usually for h-v

BANKS of single-anode elements, in this case *ignitron* type, usually make up today's mercury-arc rectifiers. The banks and associated equipment are often metal-enclosed units

MERCURY-ARC rectifiers can handle large blocks of dc power

Mercury arc is name applied to rectifiers having mercury-pool cathodes and graphite anodes operating in a vacuum. We are concerned here with *ignitron*, *excitron* and *multianode* rectifiers. The last are no longer manufactured in the United States but are still made and used in Europe. Each of these types is available in sealed and pumped forms, the designation referring to the manner in which vacuum is maintained in the rectifier tank after it has been installed.

Let's first consider ignitrons and excitrons. These are single-anode individual elements having many similar construction features. Simplified drawing of typical ignitron appears on next page. This is a sealed tank, as evidenced by the pinched-off metal tube, upper left. In the sealed or pumpless tank, vacuum is drawn at the factory and tank is welded closed. If vacuum is impaired, the tank must be returned to factory for evacuation; in some cases the sealed tube may be opened and portable vacuum equipment employed. Experience with pumpless units has been so satisfactory they are the most popular mercury-arc rectifier today. One leading manufacturer has stopped making pumped units.

Pumped units are connected to a vacuum manifold through a pipe, often located in a position similar to vacuum seal in sketch; a vacuum pump and gage are required auxiliary equipment. Flanged construction is used so tank can be disassembled for maintenance and parts replacement. Ignitors, shown being adjusted in photo at left, can be removed without tank disassembly. Proponents of sealed tanks contend that not only is additional maintenance required for the vacuum auxiliaries, but internal wear is greater in pumped types. Mercury may migrate from tank into vacuum system necessitating adjustment of ignitors which must dip into the mercury pool to a proper depth. Ignitors can't be replaced on pumpless units; two are supplied on larger units, one a spare.

Sealed units in smaller sizes (maximum of 500 kw, 250 v and 1000 kw, 600 v) are metal tubes, see p 82. Internal construction is slightly different from tanks with higher outputs, but essential parts correspond. It's ordinarily cheaper to replace the smaller tubes than return them to factory for reconditioning.

Cooling of ignitron illustrated, and all mercury-arc elements we'll discuss, is by water. Coolant flows in cooling tubes or channels between inner and outer tanks. Raw tap water is used when it meets purity and temperature needs. Otherwise water-to-water or water-to-air heat exchangers are required for closed cooling systems.

Operation of mercury-arc elements is essentially that of an electron tube. A graphite anode is spaced a suitable distance from the mercury cathode. Under proper excitation (ignition) mercury is vaporized in space between anode and cathode. During positive half-cycle of applied ac sine wave, anode is positive with respect to cathode — conduction occurs through the mercury vapor, from anode to cathode. When applied voltage is in its negative half-cycle, the anode is negative with respect to the cathode and conduction through the mercury vapor ceases.

Actually, movement of electrons during conduction is from the mercury pool to the anode. During the negative half-cycle the anode has no tendency to give up electrons, so blocking takes place. Occasionally a disruptive discharge occurs during blocking and high reverse currents flow. These discharges are called *arc-backs*.

Major differences in mercury arc are in firing, control

Operation of any mercury-arc rectifier depends on existence of an electron-emitting spot, a cathode spot, on the mercury pool. Mercury does not emit electrons freely unless vaporized, so the cathode spot is created by striking an arc on mercury-pool surface. Once started the cathode spot produces an abundance of electrons and mercury vapor for conducting anode current. The mercury-pool cathode is self-restoring; evaporated mercury condenses on walls of tank and returns to the pool by gravity. Deterioration of the cathode is not a factor as it is in hot-cathode rectifiers (p 83); heavy overload currents can be drawn for short intervals.

Ignitrons start firing by means of *ignitors*. Tips of ignitors are a semiconducting material and are immersed in the mercury pool. A pulse of current is sent through the ignitor, and at point of contact with mercury a small arc is formed. It's this arc that initiates anode current. A small *holding anode* (not shown in sketch) is usually mounted near the ignitor to assist main anode in firing and to maintain the cathode spot during light loads. Quartz ring is a *mercury separator* to insure that only clean mercury is exposed to surface on which cathode spot travels. Over long periods particles of graphite may erode from anode and grid and float on mercury surface. Separator prevents contamination of mercury pool by these particles.

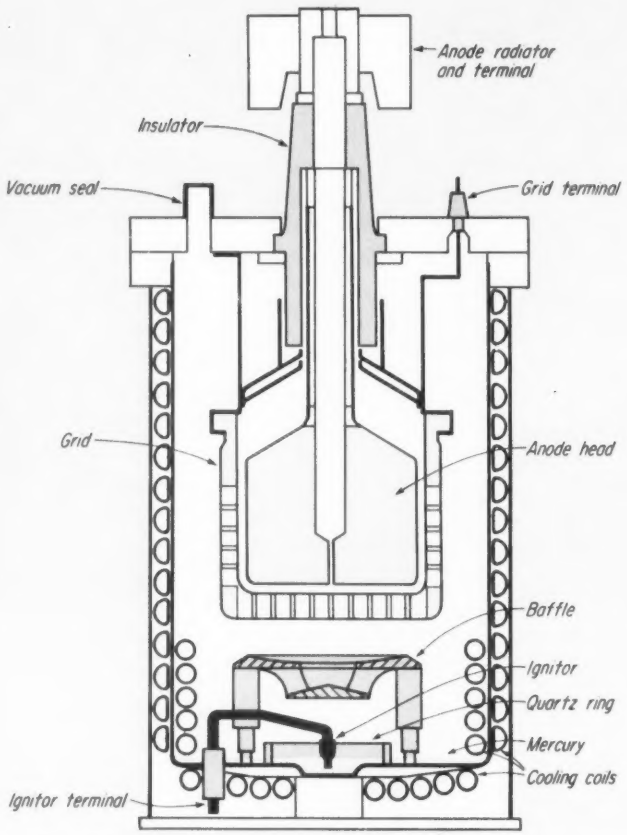
Ignition circuits for ignitrons generally resemble the simplified circuits illustrated on next page. Reactor circuits are favored for high-power tanks. For increased reliability actual circuits are generally more complicated than the circuits that are shown.

Thyratron firing uses tube of that name which conducts only when proper signal is applied to its grid. It is therefore suited to positive phase-shift control, p 73. Advantage is highly accurate and consistent operation; disadvantage is that high peak currents are required for firing which may shorten thyratron's life.

Reactor firing provides current pulses from a capacitor. As voltage from phase-shift circuit rises in positive direction, a small current flows through both linear and saturable reactors. This current is not enough to fire the ignitor, but does affect magnetization of the saturable reactor. When it is sufficiently large it saturates reactor, and reactance falls to negligible value. Capacitor, which has been charging, now discharges through the reactor and ignitor, causing it to fire the rectifier. All this happens in a fraction of a cycle; any delay is negligible.

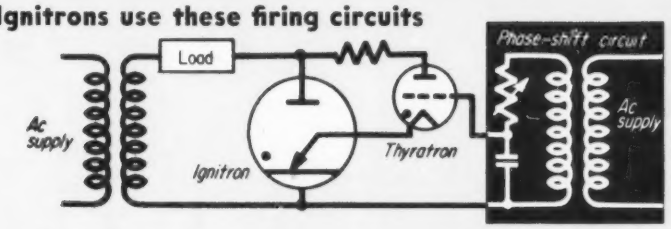
Excitrons fire in a different manner. They initiate the arc by means of a small steel plunger housed in a nonmagnetic well welded to bottom of the tank. An external solenoid around this well pulls plunger below surface of the mercury. When the solenoid is deenergized, the plunger pops up because it is buoyant in mercury. Its tip makes contact with the excitation anode, corresponding to ignitor in an ignitron. When plunger makes contact, circuit through the solenoid is closed, energizing coil. Coil pulls plunger away from the excitation anode and an arc is established which is trans-

Ignitron is typical mercury-arc rectifier

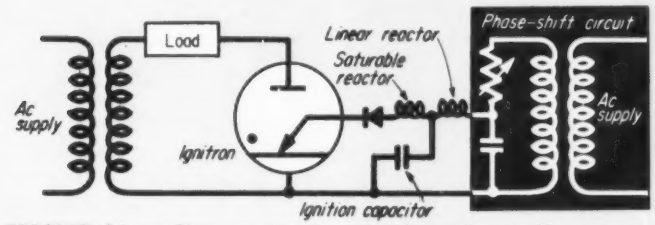


CONDUCTION is initiated by ignitor with its tip in mercury pool. When fired it draws arc, producing mercury-vapor ions for conduction

Ignitrons use these firing circuits

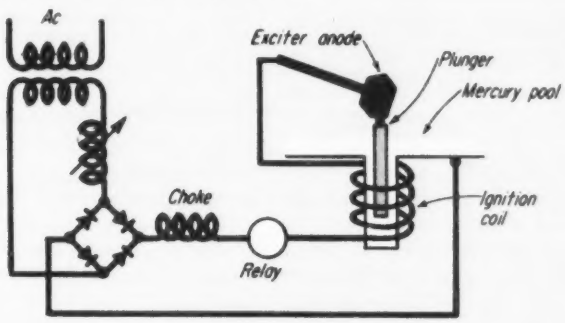


THYRATRON firing makes use of tube which conducts only when a positive voltage is applied to its grid. Signal is supplied by phase-shift circuit



REACTOR firing utilizes capacitor in conjunction with saturable reactor to obtain pulse of current. Capacitor is charged by positive control signal

Excitrons have firing solenoids



PLUNGER is housed in nonmagnetic well welded to tank. External coil actuates plunger to draw arc and initiate conduction in tank

ferred to mercury surface as plunger submerges. While arc is maintained current flows and the plunger is held down. If the arc is interrupted the plunger pops up again and automatically restores the arc.

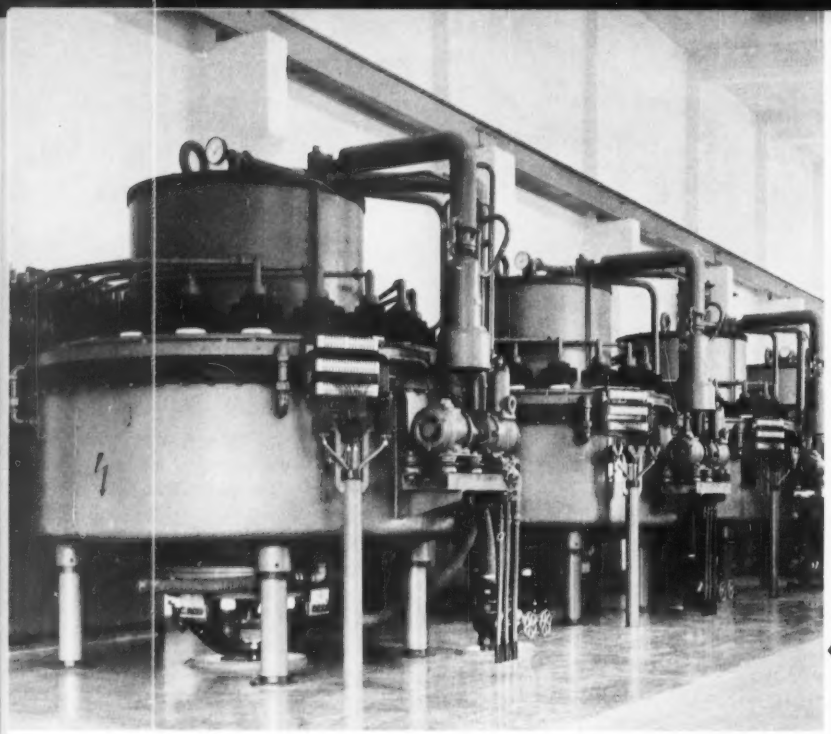
Excitation circuit of excitron is simpler than ignitron and requires less power. However, it doesn't provide phase-shift control. Where this is desired, it's obtained by separate grid control, which may somewhat offset original simplicity. Voltage is controlled on the grid, see sketch, surrounding anode.When a voltage negative with respect to the cathode is placed on grid, latter is prevented from conducting though it becomes positive with respect to the cathode. If grid is made positive at any time while the positive half-cycle of input voltage is on the anode, anode will conduct. Thus firing may be obtained at any angle of the positive half-cycle. This method is very similar to firing of a thyratron and to control of electron tubes in general.

Grid serves another purpose also in both excitrons and ignitrons. It acts as a shield for the anode, decreasing deionization time at end of conduction period (making a faster current cutoff) and aiding in reduction of arc-backs at commutation point. Some tanks are furnished with two grids, one for a shield, the other for control.

Arc-backs, as we mentioned, are an abnormal occurrence in which heavy currents flow in the reverse direction. They amount to a breakdown during blocking in which electrons flow from the anode to the cathode. Arc-backs don't occur frequently with today's mercury-arc rectifiers, but they haven't been eliminated completely. Since an arc-back is equivalent to a short circuit across the transformer, it's advisable to protect large units with anode circuit breakers.

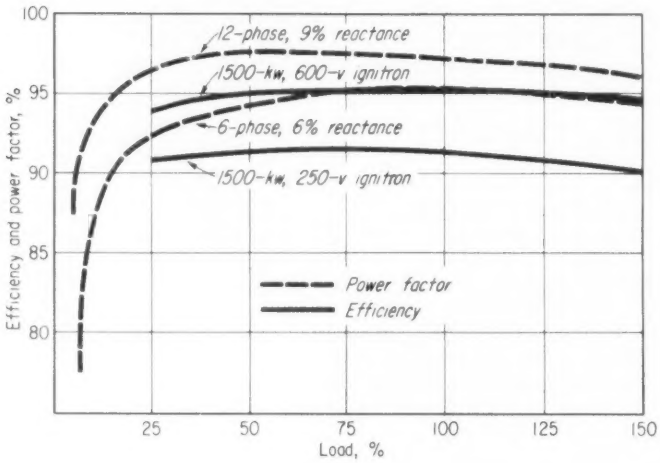
Causes of arc-backs are sometimes quite complicated, and have been the subject of much study. Simpler causes, such as mercury splashing on the anode and setting up an electron emission, have been licked by devices such as splash baffle mounted over mercury pool, shown in sketch. Interiors of tanks must be spotlessly clean and dry. At the factory, tanks are assembled in air-conditioned rooms by men wearing gloves — a single thumbprint might upset performance of the unit. Such precautions also have to be taken during maintenance in your plant, and this is a big reason for popularity of low-maintenance sealed tanks.

Reduction of arc-backs results when tanks are derated; conversely, overloading tanks tends to increase incidence of these disturbances. A word of caution may be in order, too, about operating rectifiers with voltage reduced to low levels by phase control: increased harmonics (unwanted voltages at other than line frequency) and higher commutating duty may increase incidence of arc-backs and force you to decrease rectifier rating for reliable service. Some manufacturers suggest that it is usually undesirable to operate a rectifier continuously with voltage reduced more than 15% by phase control. But for short times, as for starting motors, it may be reduced to zero.



SEALED TUBE, *left,* and tank, *right,* are typical elements used in rectifiers rated from 40 kw, 250 v to over 1500 kw, 600 v

MULTIANODE rectifier incorporates single tank, mercury-pool cathode and ignition system. Three or more anodes mount in a circle



EFFICIENCY AND POWER-FACTOR CURVE for typical single-anode rectifiers considers losses of transformers, rectifier arc and power for regular auxiliary gear

Multianode rectifiers were developed for high-power applications before emergence of single-anode tubes and tanks. A refined version is still favored in Europe. Units have been built for over 5000-kw output and up to 20-kv dc. Usual water-cooled tank has vacuum maintained by rotary and mercury pumps. Sealed, air-cooled units are available from at at least one European manufacturer.

Single large tank has three or more anode-and-grid assemblies equally spaced around a circle. There is a single pool of mercury with a quartz ring similar to those of single-anode types. Baffles are more complicated, each anode assembly being equipped with one or more. As commutation takes place the arc moves from anode to anode around the circle. *Excitation anodes* help maintain cathode spot. These are counterparts of holding anode in single-anode tank. Firing is initiated by some variation of the excitron method. One system closely resembles that illustrated on preceding page. Another has solenoid on top of tank which actuates a long rod. When the tip of the rod is withdrawn from the mercury it draws an arc. Rod is known as *starting anode.* Control of this unit is by means of a grid.

Operation of mercury-arc rectifiers may seem complicated compared with semiconductors. But on the other hand, they've been around long enough to be well understood, and have a good record for handling tough load conditions.

Dc voltage regulation for any value of phase control is determined almost wholly by transformer resistance and reactance drops. Arc drop or voltage loss is practically constant throughout normal load range. With a transformer of typical design regulation is on the order of 5 or 6%. In general, efficiency of mercury-arc rectifiers is better at higher dc voltage rating. Transformer losses are in proportion to kilowatts, but the arc loss is practically proportional to dc amperes. The lower the ratio of dc amp to kw, higher the efficiency. Pf depends on both reactive kva and wave distortion.

We have mentioned that harmonics of the supply frequency sometimes reach significant magnitude; they may disturb telephone lines and radios. Filters for ac circuits can be used to suppress them. In most industrial plants filters are rarely used.

HOT-CATHODE glass tubes suit high voltage, low current

Hot-cathode glass-bulb rectifier tubes are typical of communications equipment and have been widely used in instrumentation and control. Now semiconductor rectifiers have taken over many of these applications. For moderate dc-power requirements hot-cathode tubes may have advantages: they're simple, need no maintenance and are easily replaced, although they're not mechanically rugged and have a relatively shorter life. Speed control of small dc motors (five hp or less), welding control, high-frequency oscillator power supplies are typical loads handled by this type rectifier.

Tubes may be *diodes*, having a *plate* (anode) and cathode, or *triodes* having plate, cathode and a *grid* for control purposes. Some tubes operate in vacuum, others are gas-filled. High-vacuum tubes find application where high voltage and low current is to be rectified. Gas-filled or vapor-filled tubes are used where a large current is required. Simplest rectifier tubes are diodes. Here, when plate is positive with respect to cathode, current will flow, and when the voltage is reversed current is blocked.

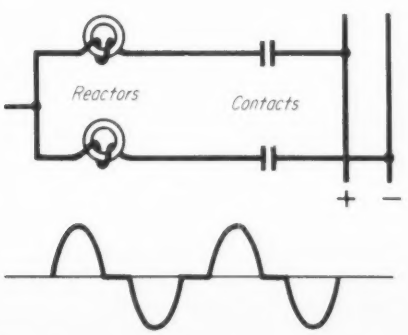
HIGHER-POWER hot-cathode tubes are shown in a rectifier rated 234 kw, 11.7 kv. This unit is the dc supply of a high-frequency oscillator generator used in a dielectric-heating process

Electron emission by cathode is produced by heating it red hot. A separate circuit and *filament transformer* is thus required. Special compounds which yield electrons profusely are frequently coated on the cathode; overloads tend to "boil off" these compounds and shorten tube life. Cold-cathode diodes and triodes also have some applications as rectifiers, generally for uses requiring small current.

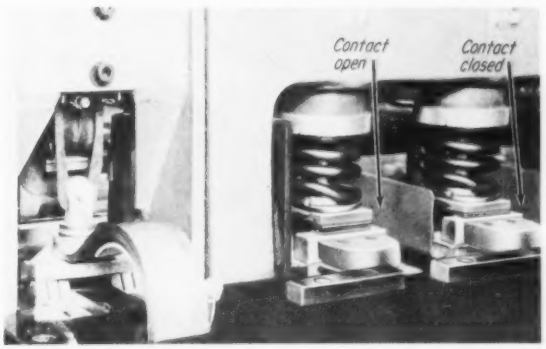
Thyratron is a typical gas-filled triode—envelope may be glass or metal. Gas is mercury vapor and electrons are emitted by a heated cathode. Grid functions in much the same manner as described for the excitron: when its voltage reaches a certain critical value it causes the tube to fire and conduction continues until the anode becomes negative with respect to cathode, although grid signal may be removed. Phase-shift control can be used with thyratrons to control dc output. Current ratings reach 50 amp.

Mechanical rectifiers were introduced a few years back and gained some acceptance in electrochemical plants because of their high efficiency (97 to 98%). Born at the wrong time, they have been pushed off the American scene by silicon and germanium rectifiers, though they have advocates in Europe. Principle is simple but requires high degree of mechanical accuracy. Metal contacts must open and close 60 times in a second. Maintenance is higher than for other rectifiers which has been big deterrent to acceptance in this country. A mechanical rectifier installation was detailed in POWER, Feb. 1954, pp 77-81.

Mechanical rectifier has its contacts synchronized



CONTACTS open and close at zero points of wave. Zero-voltage time is extended by series line reactors



MECHANISM is driven by a synchronous motor which insures that the contacts will open and close when they are carrying no current

EQUIPMENT SELECTION: For best performance know all your dc-load operating requirements

Basic choice in selecting conversion equipment, as with any electrical equipment, is cost vs performance. Three cost factors are involved: *initial*, *power*, *maintenance* costs. Performance breaks down into (1) *essential* characteristics which your process requires, and (2) *advantageous* characteristics to improve your product, increase output, assure production continuity—if you can afford them.

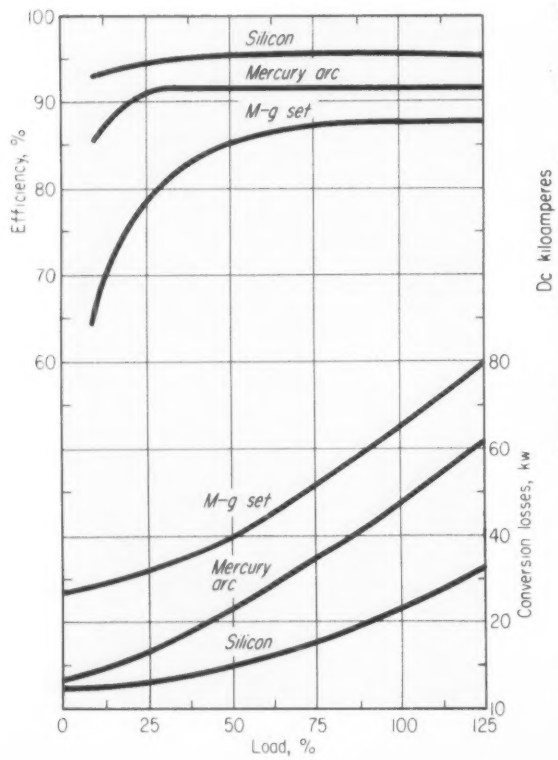
Initial cost in dollars per kw is influenced by equipment size and necessary auxiliaries; you can't make a flat statement on which type rectifier is least expensive. For a job that either selenium, m-g set, silicon or mercury arc can handle, selenium will cost least, the others increasing in order listed. With today's packaged equipment, installation costs tend to be equal. Larger m-g sets need special foundations and on-the-job alignment. Mercury arc requires at least some plumbing; silicon may or may not be water cooled as installation requires.

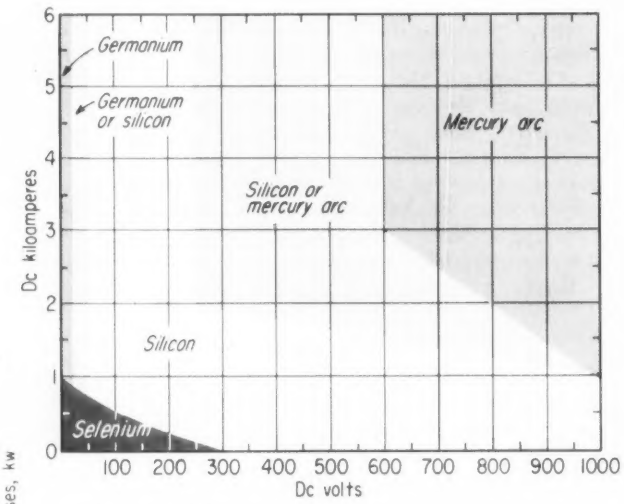
Maintenance of m-g sets involves brushes, commutators and, depending on environment, attention to windings, bearings, etc may be considerable. Apart from infrequent tank overhaul, which you probably won't want to do yourself, mercury arc requires little maintenance. Semiconductor maintenance consists almost wholly of keeping cooling system in shape. Durability of rectifiers (except selenium) is limited mainly by switchgear since elements are enclosed.

Dependability of silicon and germanium hasn't yet been pinned down completely, but it's high and may prove best. Cell failure has been estimated at about 1% per year. Rectifier equipment can be built so you don't have to shut down to replace cells. Silicon has highest dependability of any conversion equipment today, yet failure of mercury-arc tanks is rare; arc-backs are usually cleared quickly by anode breakers. M-g sets are vulnerable to many troubles but an experienced operator can often spot trouble developing and head it off.

Efficiency and conversion losses are especially important for processes such as aluminum reduction where power is a big part of total production cost. Comparison is given in chart, below. No-load losses are low for rectifiers. Power factor of silicon and mercury arc is about 95% lagging; m-g set driven by synchronous motor can be supplied with a leading power factor for pf correction.

Voltage and current ratings at which it's practical to apply different conversion equipment don't present a clear picture. Inherent characteristics of elements have been discussed previously. Manufacturers have considerable leeway in how they use these characteristics to obtain overall voltage and current ratings of conversion equipment. Semiconductor develop-

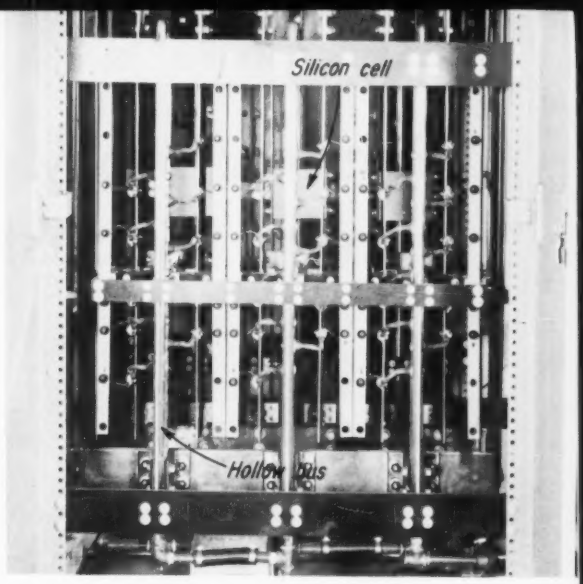




APPLICATIONS for different rectifiers can be only roughly approximated on basis of voltage and current since other characteristics of load and rectifiers must match. The silicon area is spreading

EFFICIENCY and conversion losses are here compared for typical m-g set, mercury-arc and silicon rectifiers of the same rating. On this basis, ignoring other factors, silicon has a clear advantage

DC SUBSTATION is package including ac and dc switchgear, transformers and either mercury-arc or semiconductor rectifiers, instruments and controls



SILICON RECTIFIER has numerous cells mounted in accessible positions on a hollow water-cooled bus bar

ments are changing their part of the picture almost from day to day.

Voltage regulation is easily accomplished by phase-shift control of mercury-arc rectifiers and field control of m-g sets. Voltage regulation of semiconductors must be accomplished by regulation of ac input power by magnetic amplifiers, voltage-regulating transformers or load-tap-changing. Dc voltage of rectifiers is fixed by ac voltage and transformer design. Changes in ac voltage are reflected in dc output (but may be corrected by phase shift in mercury arc and power-circuit devices in semiconductor). Synchronous-motor-driven m-g set doesn't usually reflect voltage changes of ac supply.

Abnormal conditions of operation in a particular application must be predicted and provided for. Silicon and germanium rectifiers have a definite design ceiling on overload and short-circuit capacity. Manufacturer can set ceiling wherever it's economically feasible by derating cells, but if ceiling is exceeded cells are damaged. Selenium is more generous, and has useful property of self-healing. p 78.

Mercury arc has high overload capacity; if this is exceeded an arc-back occurs, usually without damage. Short-time overload capacity of m-g sets is high. For over-voltage and over-temperature operation silicon and germanium have definite limits, with selenium not so critical. Mercury arc stands up best; occurrence of arc-backs is danger signal. Endurance of m-g sets depends mainly on insulation, but commutation is also a factor.

Starting is instantaneous for semiconductors with inrush current determined by nature of dc load. Mercury-arc units may require some warmup time before carrying full load. M-g sets need starters and in larger sizes it may be necessary to limit inrush current; automatic starting is liable to be more complicated with a m-g set than a rectifier. Power restoration after shutdown on a fault will probably take longer.

Parallel operation of m-g sets on both ac and dc sides can be achieved if generators have the same characteristics. Mercury-arc rectifiers can be satisfactorily paralleled with each other or with m-g sets if voltage regulator is designed for this purpose. Paralleled amplifying reactors and shunts may be required on the load side of each unit. Semiconductors should be designed as a system to be satisfactorily paralleled.

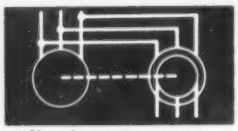
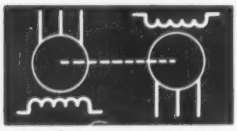
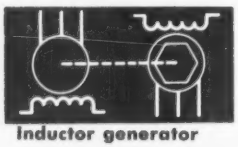
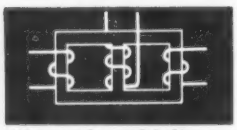
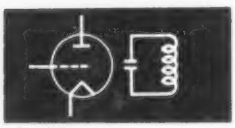
Life of silicon and germanium cells appears indefinite. Scattered cells may fail, but such failures are probably caused by original flaws which can't be detected by testing methods so far devised. There appears to be no correlation of life to age or cell service. Selenium, on the other hand, has a life span already defined in terms of aging and service hours. This runs about six to eight years. Mercury-arc rectifiers generally average ten to 20 years between tank overhauls. Life of m-g sets depends on insulation and commutators, and is greatly affected by operating conditions. M-g sets have been known to run for 40 years or more under ideal conditions without rewinds or new commutators.

Regeneration is one area where m-g sets have a definite edge. Mercury-arc rectifiers can be used as inverters to feed dc power back into ac lines, and circuits are in use which do this for reversing steel-mill drives, one of the toughest kinds of regenerative service. It is necessary to reverse the polarity of the dc-drive motor with respect to the rectifier when motor is functioning as a generator.

Because the reversal of the motor field is slow due to inductance involved, polarity reversal is usually obtained by reversing the armature connections. This requires a heavy-duty switch capable of extremely fast and frequent operation. Switching is at zero current so the only wear on the contacts is mechanical, as in the case of the mechanical rectifier. Back-to-back rectifier inverters can be used instead of armature reversal. In this case one set of tanks rectifies for driving the load and another set of tanks inverts the dc power produced by regeneration to ac for the lines.

High-frequency power finds new uses in today's industrial plants

High-frequency sources and their ranges

Converter	Frequency, cps
 Slip-ring generator	180-420
 Synchronous generator	120-3000
 Inductor generator	360-20,000
 Magnetic multiplier	120-360
 Oscillator	1000-300x10⁴

Industrial applications of h-f power

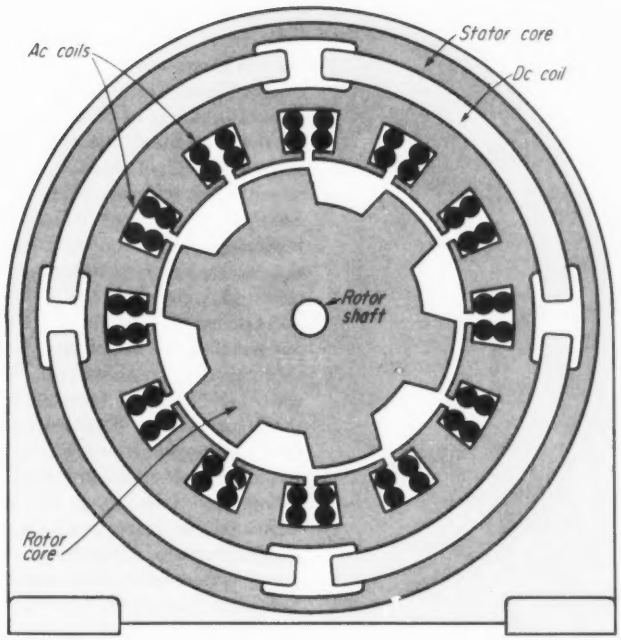
Application	Frequency, cps
Continuous-tube welding	180
High-speed tools	180-360
High-speed grinders	180-420
High-speed woodworking	180-720
Ozonators	360-500
Fluorescent lighting	360-10,000
Aviation industry	400, 600, 800
Induction heating	960, 3000, 4320, 6600, 10,000
Electroluminescence	3000
Skin-effect resistance welding	450,000
Dielectric heating	2x10⁶-300x10⁶

List of industrial processes requiring ac at frequencies higher than 60 cycles is growing steadily, and so is the kw load demanded by them. The range of frequencies employed goes all the way from 120 cycles to several megacycles. Partial list of typical applications is given in table, left. Three basic converter types are rotating generators, magnetic multipliers and oscillator generators. Each is best suited to certain frequency ranges.

High speeds (above 3600 rpm) are necessary for some processes, such as woodworking and metal grinding. And the tools used are most effectively driven directly from the motor shaft. Induction motors can supply high-speed power only if they are fed by high-frequency power since maximum rpm still equals 60 times frequency. Induction motors are simpler and more dependable than dc or universal motors at high speeds. Furthermore, there is a substantial reduction in size at high frequencies. Similar advantages are often gained in portable electric hand tools. These tools are usually of a standard design for operation on 180- or 360-cycle frequencies.

Induction heating is an important consumer of h-f power. In this process a coil supplied with h-f current acts like the primary of a transformer and work piece acts like a transformer secondary winding. Eddy currents are induced in the work piece, which must be a conducting material, and heat the work by I^2R losses. At high enough temperatures method becomes induction welding, which has many uses.

Skin-effect resistance welding at frequencies of 450,000 cps is a relatively new process which has already been adapted to some difficult welding operations including continuous-tube making from spiral-wound strip. At frequencies of this order reactance rather than resistance is major current-limiting factor. Current flows in a low-inductance path through a conductor although there is no insulation or high resistance adjacent to the path.



INDUCTOR generator has unenergized poles on rotor. They affect reluctance of stator poles, varying magnetic flux and inducting h-f voltage

This is known as *skin effect*. Low inductance path is produced by placing return conductor close to desired path. The conduction path may have enough resistance to heat material to fusion point, but its total impedance is still less than the surrounding high-inductance area. Thus it's possible to heat a small area of a large piece of metal.

Dielectric heating is a method for internally heating nonconducting materials. It is used in plastic preheating, wood gluing, drying operations, sterilizing, foundry core baking and many other processes. When a voltage is applied across a nonconducting (dielectric) material, stresses are produced in its molecular structure (so-called displacement currents). If applied voltage is alternating, these stresses reverse themselves and there is a power loss known as dielectric loss. At very high frequencies losses become significant and can cause internal heating. In dielectric heating the work piece is placed between h-f electrodes, similar to the dielectric in a capacitor. The work heats evenly, its interior simultaneously with its surfaces.

Lighting is one of several newer uses for high-frequency power (see POWER's special report, *Industrial Lighting*, June 1956.) Transducer for producing supersonic waves is another use with a future.

Rotating machines are the leading source of high-frequency power, up to about 10,000 cps, and are in use for even higher frequencies. Converter is a 60-cycle motor driving a h-f generator. Although m-g sets require more maintenance than static converters, initial cost is generally less, and they are familiar type of equipment with designs long established.

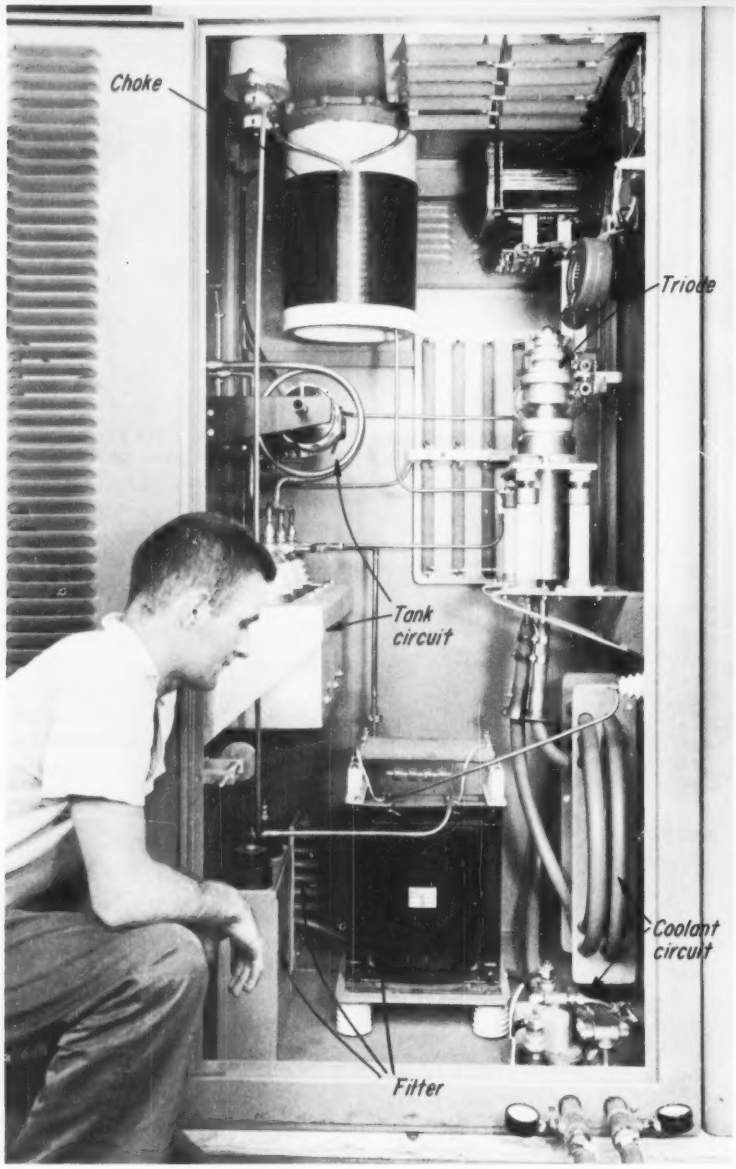
Slip-ring generator, commonly called a frequency changer, is an induction generator constructed like a wound-rotor motor. It is usually driven by an induction motor. Stator winding of generator is excited from 60-cycle supply as though it were a motor, and h-f current is taken from the slip rings. Frequency produced by this machine doesn't vary directly with driving speed. Instead, it's the sum of transformed component induced by stator winding and generated component resulting from rotor-winding rotation. Output frequency of m-g set = (rpm $\times$ poles/120) + 60 for a 60-cycle input frequency. In their h-f range these sets are a very practical source of large-kilowatt power.

Synchronous generator for high frequency is modified form of 60-cycle alternator. Stator is wound in conventional manner with proper winding for h-f output. Rotating field has many poles excited by dc coils fed through slip rings as in a conventional machine. Poles are close together and are usually formed by teeth and slots in rotor core. Appearance of rotating field is like a hybrid between a salient-pole alternator and a round-rotor type. Drive is usually a synchronous motor.

Higher frequencies are possible with this m-g set than with the slip-ring generator set. Frequency is an even multiple of the drive frequency for direct-coupled sets, and is constant with varying load and supply-voltage shifts. Since frequency depends directly on speed a wide choice is possible. Adjustable frequency can be obtained with an adjustable-speed drive. Voltage regulators can be used with synchronous high-frequency generators.

Inductor generators take over at frequencies which would require too many poles for an excited-rotor machine. Inductor generator, left, has dc-excitation winding on the stator in addition to the h-f output winding. Dc field resembles that of a dc motor; number of dc poles doesn't determine frequency of output.

Rotor poles, or teeth, are half as numerous as stator teeth. At instant shown in sketch one stator tooth is opposite a rotor pole while the stator tooth adjacent to it is opposite a rotor space. Rotor pole strongly influences the reluctance of the magnetic path including it. In other words, magnetism in a given stator pole goes from maximum to minimum as a rotor pole sweeps past it. This alternating flux induces voltage in the h-f winding of the stator. Output frequency = 60 rpm $\times$ number of rotor poles or teeth. H-f alternators and inductor generators often require series capacitors to counteract internal reactance.



OSCILLATOR GENERATOR for high-frequency resistance welding shows electronics on a high-powered scale. Unit above is 60 kw; 2400-kw units have powered induction-heating sets

Oscillators and magnetic multipliers are static frequency converters

For frequencies much higher than 20,000 cycles rotating converters are impractical. Most popular converter for the higher frequencies — up to several hundred megacycles — is the electron-tube oscillator. Circuit is essentially that used in communications equipment, but is built in ratings to hundreds of kw. Components may be water cooled. Basic triode-and-tank circuit is shown on opposite page.

Operation of basic oscillator utilizes triode (usually a high-vacuum hot-cathode tube) as a fast-acting switch. Switching is initiated by a control signal applied to tube's grid, *G*. Signal originates as feedback from h-f output. When "switch" closes for a moment, capacitor *C* is charged to nearly value of the dc input voltage. When "switch" is opened, *C* will commence a damped oscillatory discharge through the inductor *L* and resistor *R*. That is, the capacitor discharges and charges repetitively as result of the nature of the *RLC* circuit, called a *tank circuit*. Amplitude of oscillatory wave is decreased with each cycle because of losses. Rate depends on damping ratio $R/2L$. If, however, the "switch" is closed at the proper moment, the amplitude will again be raised to the dc input value. Since triode operation is properly timed by the feedback signal, a maintained oscillation of constant amplitude exists in the closed tank circuit.

Ac power is thus induced in the output winding and supplied to the load at frequency of about $1/(2\pi\sqrt{LC})$ cps. Direct current required for the oscillator input is obtained from the 60-cycle supply by using a rectifier. Filtering may be needed to further reduce ripple. Fast action of the tube makes very high frequencies possible.

Other types of oscillators don't employ electron tubes for the switching operation. Transistors have come into the picture recently, and are at the heart of latest h-f converters for fluorescent lighting. Action of transistor is essentially same as that of tube, and wider use is just waiting for improvement in price, dependability and size of power transistors. Before development of high-power triodes, switching action was obtained by a device consisting of a series of arc gaps. *Spark-gap oscillators* are still used occasionally. Circuit differs from triode oscillator; input is 60-cycle ac. *Arc oscillators* are still another variation.

Inversion of dc to ac can be accomplished with mercury-arc elements. Frequencies obtained are ordinarily low (up to about 1000 cps) compared with oscillators, owing to time required for deionization of the arc path. Thyratrons may be used as inverters up to 15,000 cps for relatively low-power load requirements.

Typical h-f inverter, right, has each of two elements conducting alternately, producing alternating flux in the transformer core and ac in the load. Separate excitation from an external source is shown; it's possible to derive a suitable control voltage for the grid circuits from the output transformer.

Once initiated, conduction continues in mercury-arc elements unless anode is made negative with respect to cathode. In the 2-element inverter conduction of one element causes anode of other element to become considerably negative for a short time and extin-

guishes its arc — because of charge accumulated on the capacitor. So conduction period depends on control signal and can be a fraction of the input ac period. Fundamental frequency of output is that of the exciting source.

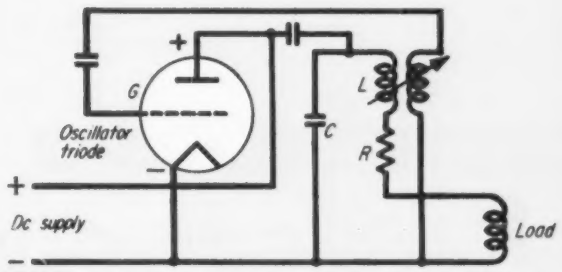
Frequency multipliers are static converters resembling magnetic amplifiers. Several circuits have been worked out. One limited use is for h-f fluorescent lamps (competing with motor-generator sets and transistor oscillators). They have also been proposed as a speed-control method for standard 3-phase induction motors. Basic 1-phase circuit is shown, right.

Magnetic core has multiple windings. Input 60-cycle winding is on two outer legs of core; h-f output winding and dc winding are on the center leg. When no dc is applied to center leg, no flux passes through it and no voltage is induced in output winding. Under these conditions the two outer legs closely approach saturation, but don't reach it. If dc is applied to center core, resulting flux passes through outer legs of the core and is such that at any instant it increases the flux in one outer leg while decreasing it in the other. Difference in flux in outer legs passes through the center leg, and has twice the reversals of flux in outer legs, so voltage induced in output winding has a frequency twice that of input windings. Idealized waves are illustrated. A smoother output wave (desired for motors) is obtained by superimposing two output waves which are 180 deg out of phase with each other, approximating a sine wave.

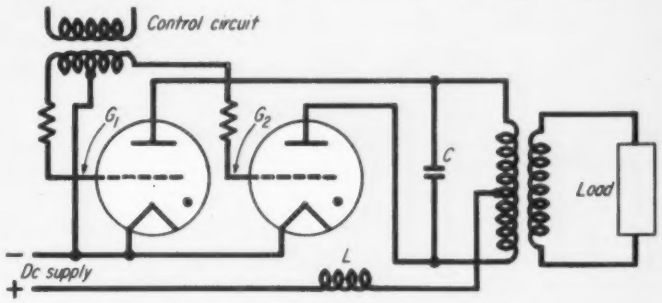
Frequencies higher than 120 cycles can be obtained by multiple stages of the doubler; frequencies higher than 360 cps have not yet been economically feasible. When control dc is obtained from semiconductor rectifiers, the frequency multiplier becomes as maintenance-free as any dry type transformer. This is its major advantage, which can be considerable in a commercial building, for example, where maintenance men may not be acquainted with care of m-g sets.

More detailed discussion of frequency multipliers can be found in these AIEE papers: *Two-phase motor drive using static frequency doubler amplifiers*, by Dick, Biringer and Slemon, No. 57-631; *Three phase induction motor control using static frequency doublers*, by Straughen, Biringer and Slemon, No. 58-68.

Oscillators and inverters produce very h-f

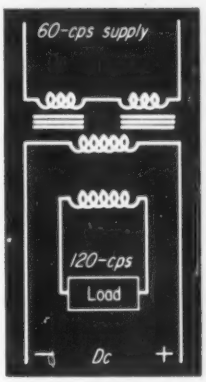


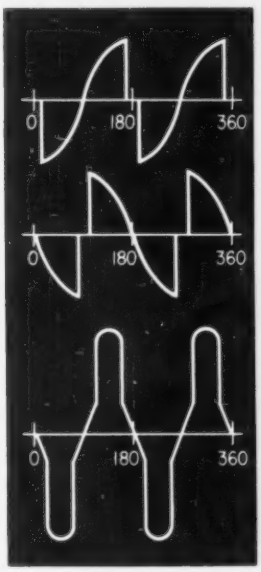
OSCILLATOR using triode and tank circuit consisting of inductance, capacitance and resistance produces alternating waves near sine shape



INVERTER makes use of mercury-arc elements to change dc to ac of the desired frequency. A grid is usually employed for control of inverter firing

Frequency multipliers are magnetic devices





SATURATION of core by dc control winding determines what part of input wave will appear at the output. Superimposing two such waves yields a smoother alternating wave at the output terminals

A look ahead—

shows important roles to be played by electric conversion equipment as many new – and some old – industrial processes make increasingly severe demands on plant power supplies. Research and development of both direct-current and high-frequency converters is being carried on by several electrical manufacturers with a variety of end uses in view. New applications for existing devices are being explored by engineers

Silicon controlled rectifier will grow up

It's a safe bet that this device, a husky infant now, will be handling man-sized loads in not too many years. Potentially it's capable of performing the controlled-voltage operations now being done by mercury-arc rectifiers and thyratrons. In control circuits it will often replace relays, magnetic amplifiers and power transistors. Field control of direct-current motors may well be an important application, and dynamic-braking schemes another. Research is going on at top speed

Door opens for new rectifier applications

Introduction of small, mechanically rugged silicon-rectifier cells has sparked some new thinking on use of dc on a localized basis. We have already discussed brushless generators, p 69. Now ideas are hatching on how to insert dc into ac motors in order to obtain adjustable speed. In control circuits and protective relaying, a handy source of dc at any place you want it is simplifying problems. Tests indicate that today's rectifiers are suitable for closing coils of power circuit breakers

Thermoelectricity broadens dc horizons

Recent developments in thermoelectrics should be felt in the industrial field in the not-too-distant future. Unidirectional current flow through thermocouple produces heat in one direction, cooling if current is reversed. Applications on the way include compact water purifier employing evaporation and condensation, and local dc generation using waste heat. Since 1950 efficiency of thermoelectric materials has increased sevenfold. Rectifiers will be needed with most of these devices

High-frequency power spreads out

Once confined to industries which demanded it for their major operations, h-f is now moving into many plants as a way to do some jobs better than before. Local or portable converters are used in much the same way that small air compressors have been. A few plants have already gone in for h-f distribution, and you can expect that more will. H-f distribution is an area where there's a lot to be learned. Next few years should show how theory works out in practice, spurring development of new h-f devices such as busway and motor starters

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By J R BERMINGHAM
Manager, Utility Application Engineering
Leslie Co

Higher-capacity, wider-operating-range feedwater heaters make control specification a ticklish problem. In this 2-part discussion we'll try to answer the question . . .

What's your plant's best heater-drain control?

Increasing numbers of chief engineers face the problem of operating large-sized boiler-turbine-generator units over widely varying load changes that occur frequently.

Since World War II, growth in size of boiler-turbine-generator units has made selection and application of heater-drain controls and engineering involved much more exacting.

Design factors which contribute to tighter control requirements stem from this trend to higher capacity and wider-range operation. As unit sizes soar beyond the 200-mw rating, through flow in feedwater heaters becomes very high relative to storage capacity of level-control area. Maximum amount of feedwater is heated in minimum amount of power-plant space. This condition is particularly noticeable in designs where vertical heaters are used and in horizontal heaters where subcoolers occupy a major portion of condensate space.

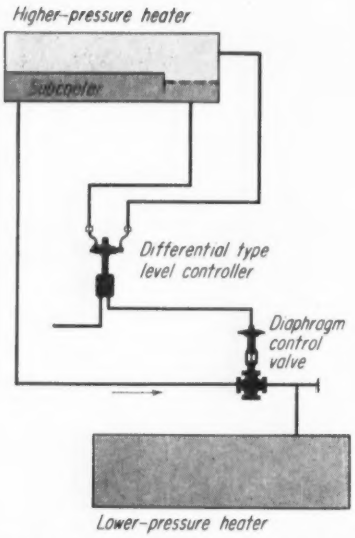
Need to handle wide range of load swings during a 24-hr period is second factor forcing more exacting selection of heater-drain controls. This brings into play many factors not apparent in large-sized base-loaded units. Variations in load over wide ranges at frequent intervals mean the control system must be stable under all conditions to eliminate adjustment or tuning by operating or instrument personnel as changes occur.

Feedwater-heater systems usually incorporate various combinations of three basic drain-control systems common to all modern power stations: (1) Conventional cascade system, where higher-pressure heater drains directly to lower-pressure heater or condenser with level-control valve located in the line between the two vessels. (2) Similar to system 1 except heater is drained by a condensate pump and level-control valve is between pump and lower-pressure heater. (3) Differs from system 2 in that heater drain pump discharges into relatively constant-pressure system such as suction side of boiler-feed pump or discharge of main condensate pumps.

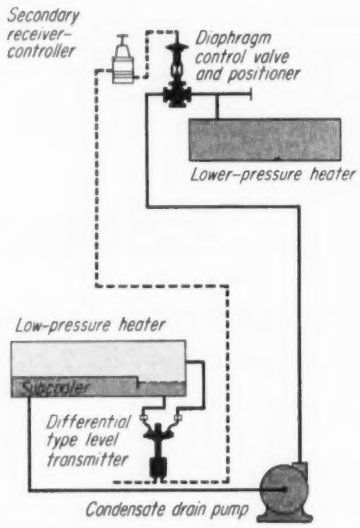
Design requirements for feedwater-heater level controls which must be met in normal and emergency operation for efficient automation include: Station should start, rise to full load and shut down with all heaters in service. All heater controls should function properly throughout load changes and even under machine trip-out at full load. Tripping of bleed or extraction steam valves due to high heater levels should not be tolerated. No high-level or low-level alarm should be allowed during any of these periods. Controls should be capable of operation over long periods of time with minimum of adjustment and maintenance on part of operators.

continued

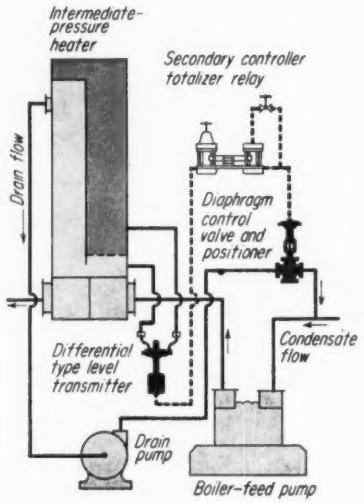
Three basic control arrangements handle most heater cycles



CASCADED type makes up majority of heater systems and uses simplest controls



PUMPED DRAIN to lower-pressure heater requires addition of secondary controller



QUICK RESPONSE to changes in feedwater-pump flow depends on totalizer relay

Characteristics of the heater and unit operation must be taken into account when heater-level control system is designed. Extraction pressure vs load must be established as well as drain flow vs load and drain temperature vs load. Physical construction of the heater must be considered to determine the needed level-control limits.

Cascaded heaters have a built-in regulating action. Pressure- and temperature-vs-load curves show three important characteristics of this heater system: (1) As generator output decreases, pressure differential between higher and lower-pressure heater decreases. (2) As differential between heaters decreases, through flow decreases. (3) Subcooling section of heater keeps condensate well into subcooled zone at all loads, but a small amount of flash occurs at 25% of full load or above.

By a simple calculation, we find that the variation in required flow coefficient, C_v, is low as the load varies from 25 to 100%. Thus the C_v requirements vary in this type of situation in a ratio of about 10:1 from minimum to maximum load.

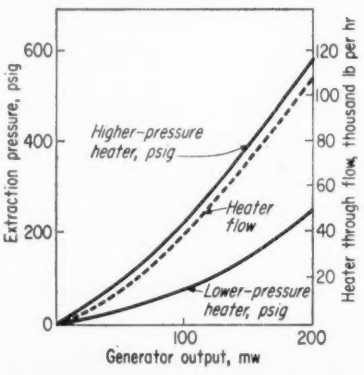
When there is a pump involved in the drain circuit, pump characteristics must be known and pump-discharge pressure vs flow enters into selection of control equipment as well as effect of submergence head on flow. Normally the designer will hold submergence head well above minimum values. Curves, far right, represent these general characteristics, common to control systems 2 and 3.

Pressure differential curve, right center, shows that as generator output decreases, pressure differential between pump discharge and next lower heater increases. During this period the flow decreases. Generally this system is designed so there is little or no flash under these conditions. Because situation is just the opposite of system 1, variation in flow-coefficient requirement is high, often approaching 50:1.

Curves showing discharge to pump suction, far right, indicate a situation similar to control system 2, except that where control system 3 is involved, pressure differential between heater-drain-pump discharge and boiler-feed-pump suction increases only slightly as generator output decreases. As a result of this, variation in flow-coefficient requirement is somewhat reduced, to the 25:1 range.

After the problem has been analyzed with these factors in mind, desirable characteristics of the actual control equipment can be specified. In writing specs for this equipment,

Characteristics of



SELF-REGULATION of cascaded heater drains results from heater differential

remember that control system 1 tends to be self-regulating and has relatively low rangeability requirements.

It is also important to remember that control systems 2 and 3 are not self-regulating and can have extreme rangeability requirements. We can then calculate rate of level change that exists or may be created in the heater. We are told the maximum deviation from level setting that will be allowed by designer. Equipment selected must adequately handle maximum level change rates and also maintain established level tolerances.

Then, we have to relate these requirements to the control equipment commercially available today.

Control equipment breaks down into several categories. First, there are level-sensing units, including level controllers or transmitters. These are either differential or displacement types. Secondary controllers or relays are available as receiver-controllers, manufactured with variable set point and reset, or with variable set point, proportional band and reset.

Other secondary control relays are the various functional relays available as 1:1, 2:1, 1:2 booster relays and the rate-action relays available with inverse and direct derivative functions. Some of these relays are manufactured with variable set point, others are not, but each modifies the transmitter characteristics differently.

Final-control-element positioners include standard bellows or diaphragm types available to operate over full range or for split-range action. Also available are the characterized or cam-action valve positioners which are valuable in tailoring proper valve characteristics.

Present heater design frequently demands that rate of level change approach 300 in. per minute when we are attempting to hold the heater level within ± 1 in. With maximum change rate, level is actually in the controlled band for a period of only 0.4 seconds—it literally goes through the band in less than the wink of an eye. This naturally calls for fast action on the part of the control system.

This situation also demands that the sensing element receive its information with regard to level position instantaneously, with no time lag. It further requires that the sensing element have a resolution sensitivity in terms of small fractions of an inch.

When this high rate of change is encountered, heater designer invariably asks control manufacturer to hold levels to a close tolerance. This calls for very fast and accurate control elements in the primary and secondary air circuits.

Secondary-control-circuit characteristics often become very important when you have high-speed changes in level. In the larger systems, flow, velocity noise and control-valve characteristics are factors, due to increased flow and possibility of creating unwanted level changes.

Effect of these factors must be given adequate weight in your analysis so equipment selected will have suitable characteristics for proper control. In laying out the control system, other characteristics of the heater, as well as the level controls, must be taken into consideration. There may be various level gradients within the liquid area on condensate side of heater because of high steam and condensate velocities across tubes and in small restricted spaces. Impulse lines for differential type sensing elements and float cages for displacement sensing elements must be located where impulses are certain to reflect actual heater conditions.

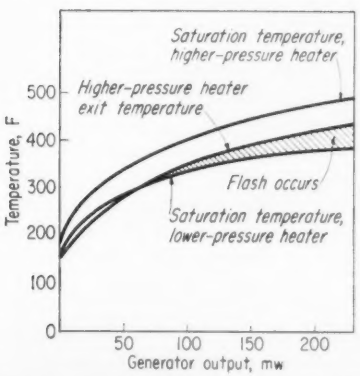
Auxiliary functions of the control system must also be taken into account at this stage. Consider split ranging of control valves, transfer of control functions for emergency operation and part-load operations, telemetering of level to a centralized point.

We'll complete our system analysis by discussing control-valve characteristics, selection of correct equipment and calculations for sizing valve internals—in an upcoming issue.

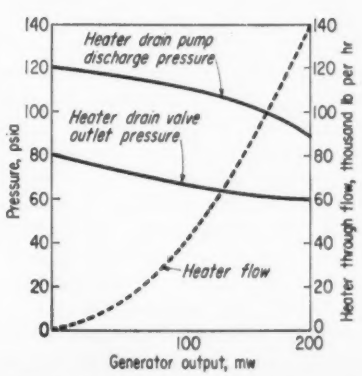
Correction

In Nov 1959 issue, p 79, "Converting to gas firing?", end of third line, second column should read "on the basis of O_2", not "CO_2".

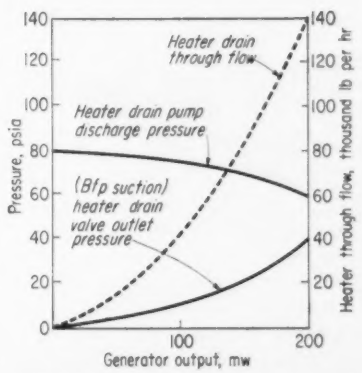
heater cycles dictate control-system performance requirements



DRAIN TEMPERATURES indicate some flashing takes place in valve at high loads



PUMPING DRAIN to lower-pressure heater exaggerates control-range requirements



PUMP SUCTION offers more stable pressure level, requires less control range

Feed-pump drives — have you checked them all?

Growing power input to large boiler-feed pumps calls for close re-examination of all possible drive arrangements. Start with the three basic ones: electric motor, mechanical-drive steam turbine and main turbine generator

By E J BLACKWELL, Chief Application Engineer, Centrifugal Pump Dept, Allis-Chalmers Manufacturing Company

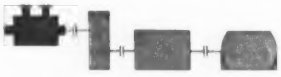
Electric motors are most popular for units up to 200 mw

SIMPLEST ARRANGEMENT possible is direct-connected induction motor at 3580 rpm

VARIABLE-SPEED unit between pump and motor saves hp during light load operation

TWO SMALLER-HP MOTORS in tandem ease voltage-drop problems during startup

GEAR-DRIVEN high-speed pump reduces stages, shaft span and barrel diameter



VARIABLE-SPEED DRIVE for high-speed pumps again gives light load savings

Probably the simplest boiler-feed drive arrangement is a direct motor-driven pump running at a nominal 3600 rpm. At part load, however, throttling in the boiler-feed regulating valve wastes considerable power. Where pressure drop across regulator is high, valve maintenance can be a very serious problem.

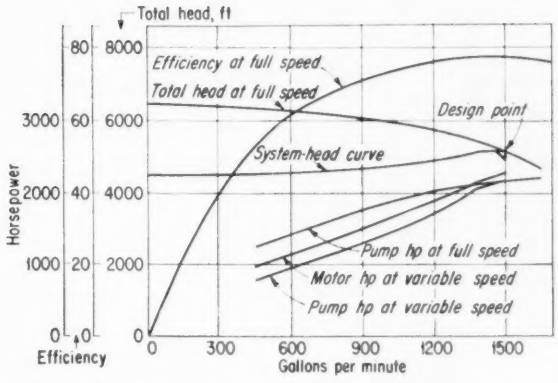
Power losses at light loads are minimized by driving through a variable-speed coupling. But remember power loss in the coupling itself. This loss is even more significant in closed cycles and supercritical boiler applications. Here the system curve is steeper and the range of operating speeds wider. However, the pump runs at reduced speed and delivers only the flow and pressure required by the system. And it operates at a more favorable point on its characteristic curve, increasing pump efficiency slightly. This offsets part of the loss in the variable-speed coupling.

For large boilers, two motors are sometimes used in tandem, each rated at half the total horsepower. Motors are started singly to hold voltage drop within limits. And station auxiliary power system may be modified with attendant savings in cost.

Don't overlook speed increasers. A high-speed pump costs less than an equivalent 3600-rpm pump. And a less-expensive 1800-rpm motor can be used. Cost of the necessary speed-increasing gear will usually be offset by savings in pump and motor. But you must take gear losses and possible lower motor efficiency into account when evaluating high-speed pumps. In cycles where the boiler-feed pump takes its suction from an open deaerating heater, booster pumps are frequently needed to meet the npsh requirements of high-speed pumps. These booster pumps are usually operated at 1800 rpm to cut their own npsh requirements.

In very high-pressure installations (throttle pressures over 2400 psig), high-speed pumps become an even better bet. At 3600 rpm, number of stages would be prohibitive and shaft span too great to produce the needed flow and developed head. Possible solution might be to reduce number of stages and increase impeller diameters. But this would increase barrel diameter and bolting stresses. On the other hand, pumps running at 6000 to 9000 rpm develop higher heads per stage with even smaller impeller diameters. This reduces number of stages, shaft span between bearings and overall length of pump. Shorter shaft spans and higher operating speeds let the designer use smaller diameter shafts for horsepower transmission and improved flow conditions at the impeller inlet.

How to calculate savings through variable-speed drives



PERFORMANCE CURVE for variable-speed high-pressure pump shows hp savings available at reduced-load operating conditions

A large boiler-feed pump is rated 1500 gpm against a total head of 5150 ft. When pump operates at a partial load of 600 gpm at constant speed, total developed head is 6275 ft. At a pump efficiency of 61%, 1400 hp is required. Driving pump at variable speed produces only flow and developed head required by the system head curve at about 3000 rpm; this is 600 gpm against a total head of 4600 ft. Pump efficiency is now 66% and required hp only 950, so 450 hp is saved.

If a variable-speed coupling is used, its efficiency under these operating conditions is about 82%. Motor output hp is then 1160, but saving is still 240 hp. At full pump rating, however, there is a slight hp loss through the variable-speed coupling. Therefore motor output hp exceeds pump required hp by a slight amount. But since capacity margin over normal full-load turbine-generator requirements is built into the pump head-capacity rating anyway, this condition is rarely encountered.

Mechanical-drive steam turbines gain in larger units

TURBINE DRIVE gives variable speed, no need for separate drive component

HIGH-SPEED turbine drive combines variable speed with smaller pump and turbine

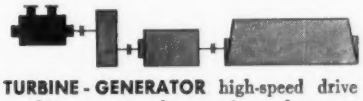
Steam-turbine-driven boiler-feed pumps can be either the nominal 3600-rpm type or high speed. Turbines permit speed control without a variable-speed coupling. If margin used in figuring boiler-feed pump flow and pressure during plant design stage was too liberal, turbine speed can be lowered slightly without efficiency loss encountered in a motor and variable-speed-coupling arrangement. Turbine speed may be increased to take care of any lowering in capacity and head capability due to wear in the boiler-feed pump. Also, turbine drive permits installing mechanically duplicate pumps in two adjacent generating units of slightly different size. Pump speed can be varied up or down to produce desired new flow and developed head.

When a high-speed pump looks best, a turbine driver eliminates speed increaser. Steam turbines offer special advantage in supercritical plants where ratio is high between the power required to drive the boiler-feed pump and generated power.

Turbine-generator drive saves money in largest units

DIRECT-CONNECTED turbine-generator drive saves motor, reduces auxiliary load

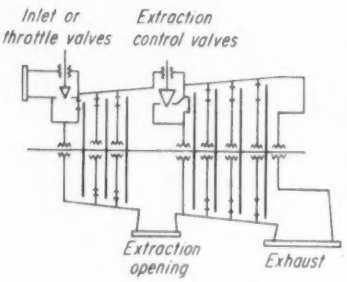
VARIABLE-SPEED DRIVE avoids a direct pump to turbine-generator connection



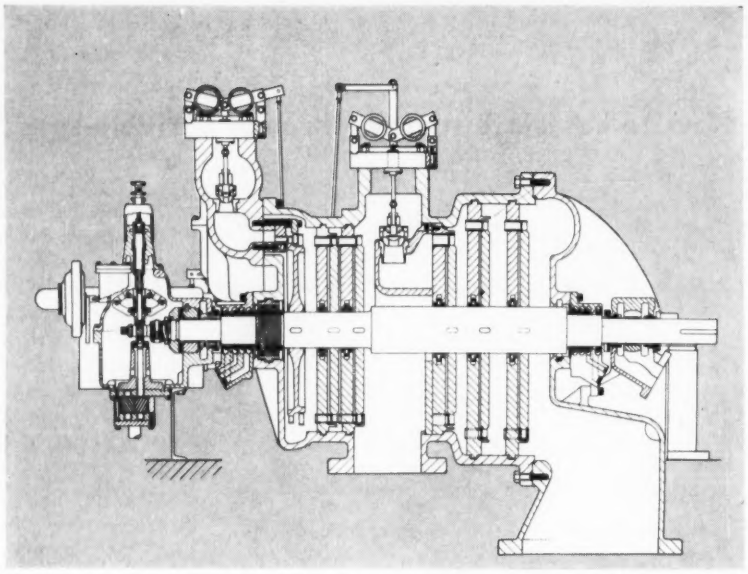
TURBINE-GENERATOR high-speed drive combines cost and operating advantages

Main turbine-generator-driven boiler-feed pumps are becoming more popular in the largest units. They may be direct connected or driven through a variable-speed coupling. Turbine-generator drive eliminates motors and main switchgear or mechanical-drive turbines and steam piping.

Where variable-speed couplings are used, they are equipped with a magnetic brake on the output shaft. Then with the turbine generator still carrying load, the coupling can be declutched and the brake applied to stall the boiler-feed pump. This permits boiler-feed pump maintenance without load interruption. When half-capacity boiler-feed pumps are used on cross-compound units and one pump is out of service, other pump is capable of carrying more than half station load. With high-speed pumps and gears, it is frequently possible to take out the generator rotor without having to break the boiler-feed-pump piping. Only gear and variable-speed coupling need be removed from the foundation.



1 Schematic layout identifies parts of turbine section detailed in Figure 2



2 Single automatic-extraction condensing turbine has two sets of valves to control steam flow entering turbine and to hold the extracted steam at a constant pressure

To predict performance of a turbine we must know the conditions under which it will work. With this data in hand we can use these curves to figure performance of . . .

Condensing automatic-extraction turbines

By RICHARD SHIFLER, Thermodynamic Design Engineer,
Small Steam Turbine Dept, General Electric Company

Variable process-steam and power demands create an ideal situation for applying an automatic-extraction turbine. This is actually two or more turbines built within one casing in various combinations of noncondensing and condensing types. More common ones are:

(1) Single automatic extraction, condensing
(2) Single automatic extraction, noncondensing
(3) Double automatic extraction, condensing and noncondensing

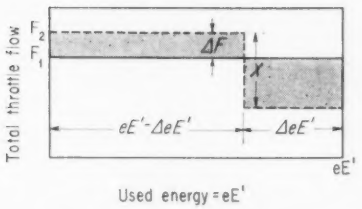
Most of these units are single-automatic-extraction condensing, combining a noncondensing and condensing turbine in series, Fig. 1 and 2. A set of "throttle" or inlet valves and a set of extraction valves control the steam flows to and from the turbine. A condensing automatic-extraction turbine for mechanical drive usually produces shaft power for compressors or pumps as part of a process system and supplies variable quantities of steam at a controlled pressure between throttle and condenser pressures. These versatile drivers run over a wide range of loads and extraction flows, ranging from zero flow to the maximum design flow.

Individual sections of the turbine operate at best efficiency at different conditions of flow. Inlet section is best at high loads and extraction flows while the exhaust section is best at high loads and zero extraction flow.

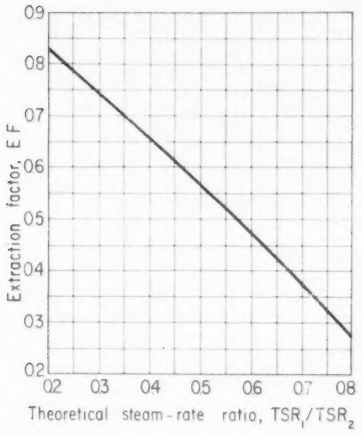
Extraction turbines experience distortion of energy distribution in providing the desired extraction pressures and have throttling losses in their extra set of extraction-control valves. This makes them less efficient than a combination of straight-condensing and straight noncondensing turbines but they do have thermodynamic gains where the application involves a wide range of loads and extraction flows.

Extraction turbines designed for about the required amount of extraction steam flow will have better efficiency than those designed for excessive flow margin. The designer must balance present and future requirements to obtain best performance with adequate reserve capacity for possible future need. Important operating points should be specified because the turbine designer can often favor these conditions.

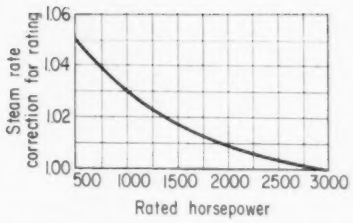
Performance for automatic-extraction turbines may be estimated from certain rules relating behavior



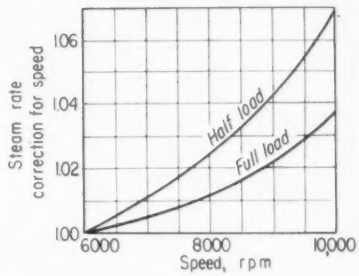
3 Areas under solid and dashed lines are equal for a constant turbine shaft load



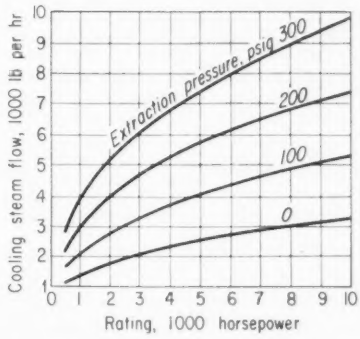
4 Extraction factor drops as the TSR ratio of parallel steam flows increases



5 Comparative steam rates for large turbines are lower than for smaller units



6 As design speeds rise above 6000 rpm steam rates increase for all unit loads



7 Cooling-steam flow needed depends on both rating and extraction pressure

at various loads and flows. Extraction factor (EF) is the fraction of a pound of steam that must be added to the zero-extraction throttle flow for each pound of extraction flow to maintain a constant power output.

Extraction factors are directly related to the TSR ratio. In Fig. 3, turbine load is the area of a rectangle with one side representing throttle flow F and the other the used energy eE' (e = efficiency; E' = available energy). If steam flow X is extracted from the turbine and the exhaust-section used energy is $\Delta eE'$, then to hold same turbine shaft load:

$$\Delta F(eE' - \Delta eE') = (X - \Delta F)\Delta eE'$$

Clearing and transposing:

$$EF = \Delta F/X = \Delta eE'/eE'$$

$$= \frac{\text{exhaust-end used energy}}{\text{total used energy}}$$

Extraction factor is an empirical relation that may be plotted as a function of TSR ratio since $TSR_1 = 3413/E_1$ and $TSR_2 = 3413/E_2$.

$$\frac{TSR_1}{TSR_2} = \frac{E_2}{E_1} = \frac{\text{(available energy from inlet to extraction)}}{\text{(available energy from inlet to exhaust)}}$$

Fig. 4 plots extraction factor vs the TSR ratio for a turbine.

Estimating method we give here is limited to turbines falling in the following range of criteria:

(a) Flow ratio, (max throttle flow) / (zero-extraction full-load flow), is less than or equal to 3.0

(b) Ratio of inlet pressure to extraction pressure is greater than or equal to 2.0

(c) TSR_1/TSR_2 lies between 0.2 and 0.75 inclusive

(d) Speed is between 3600 and 10,000 rpm.

Extremes of all these conditions may not be mutually compatible but the method gives reasonable accuracy for initial studies of most turbines falling within these criteria.

Part 9, Sept 1959, pp 80-82 gave the basis for estimating rated-load steam rate for nonextracting condensing turbines. Because the head end of an automatic-extraction condensing turbine runs at a fraction of its design flow at zero extraction, the full-load steam rate as estimated for nonextracting condensing turbines must be modified by a factor from Table 1*a*. At half load the normal half-load steam rate factor of 1.08 (Table 1*b*) for nonextracting condensing turbines must be increased by an additional half-load steam-rate factor from Table 1*c*. For low-power

Table 1
Performance corrections

a. Rated-load steam-rate factors for extraction turbines

TSR_1 / TSR_2	Flow ratio ≦1.5	2.0	2.5	3.0
0.20	1.02	1.02	1.025	1.03
0.30	1.02	1.025	1.035	1.04
0.40	1.02	1.03	1.04	1.05
0.50	1.02	1.035	1.045	1.06
0.60	1.02	1.04	1.05	1.07
0.70	1.02	1.045	—	—

b. Half-load steam-rate factor for nonextracting condensing turbines = 1.08

c. Half-load steam-rate factors for extraction turbines

0.20	1.06	1.065	1.075	1.085
0.30	1.06	1.075	1.09	1.105
0.40	1.06	1.085	1.105	1.125
0.50	1.06	1.095	1.12	1.15
0.60	1.06	1.105	1.14	—
0.70	1.06	—	—	—

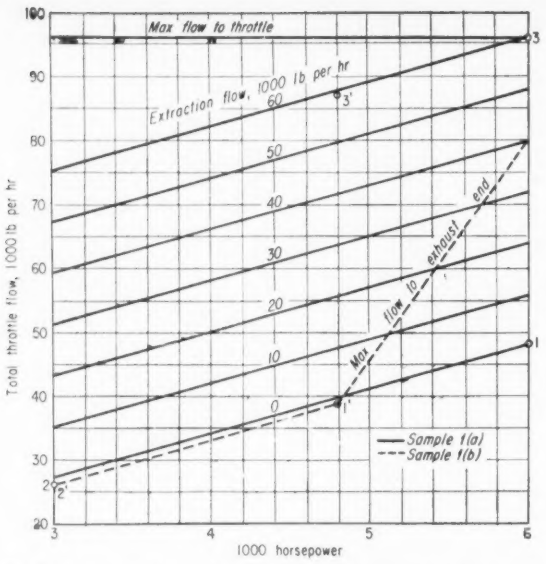
Half-load steam-rate factor for extraction turbines = (Nonextraction half-load factor) × (Extraction half-load factor)

turbines and high-speed units additional corrections for rating and speed must be made from Fig. 5 and 6.

Maximum throttle flow is determined by adding to the zero extraction full-load flow a flow equal to the product of the required maximum extraction flow and extraction factor. A value of maximum required extraction flow that is easily divisible into a number of smaller flows is usually chosen for ease of plotting the extraction characteristic curve.

Cooling steam is needed in the exhaust end of the turbine to remove heat of rotation losses when operating with maximum extraction. Cooling steam consists of packing leakage through the extraction diaphragm plus additional steam introduced through an orifice if necessary. Fig. 7 gives the cooling-steam flows.

Sample problems, right and below, show method of constructing an extraction - turbine characteristic as given in Fig. 8. Method uses curves given in Part 9, Sept 1959, and on the preceding pages. This method is based on the fact that a Willans Line of throttle flow vs power output for various extraction flows is essentially a straight line parallel to the zero - extraction - flow Willans Line. Problem 1*b*, below, illustrates a method of improving extraction performance by designing in favor of extraction operation.



8 Performance of 6000-hp tubine at 7000 rpm, 600 psig, 750 F, 3-in. Hg abs, 150-psig automatic extraction, as figured below

Problem 1*a*—Fig. 8

Steam conditions: 600 psig, 750 F (261-F sat), 3-in. Hg abs, automatic extraction at 150 psig
Rating and speed: 6000 hp and 7000 rpm Maximum extraction flow: 60,000 lb per hr
Turbine design with maximum load at zero extraction flow and rated extraction pressure

Step A—Find theoretical steam rates and extraction factor

1. TSR_1 from inlet to exhaust, Fig. 1, Part 9, *Power*, Sept 1959, p 80, lb per hphr 5.5
2. TSR_2 from inlet to extraction, Fig. 2, Part 9, *Power*, Sept 1959, p 80, lb per hphr 23.8
3. $TSR_1/TSR_2 = 5.5/23.8 =$ 0.231
4. Extraction factor, Fig. 4 ..... 0.803

Step B—Find full-load zero extraction throttle flow (point *1*, Fig. 8)

1. Base efficiency for nonextraction turbine, Table 1, Part 9, *Power*, Sept 1959, p 82, $0.698 \times 1.029 \times 0.989 = 0.711$
2. Base throttle flow (zero extr, full load) $= \dfrac{TSR_1 \times \text{rated load}}{\text{Base efficiency}} = \dfrac{5.5 \times 6000}{0.711}$ (lb/hr) 46,400
3. Base flow ratio $= \dfrac{\text{Max extr flow (A4)} + \text{(B2)}}{\text{(B2)}} = \dfrac{60{,}000 \times 0.803 + 46{,}400}{46{,}400} = 2.04$
4. Full-load steam-rate correction for extraction turbine, (Table 1*a*) × (Fig. 5) × (Fig. 6) $= 1.022 \times 1.00 \times 1.005 = 1.027$
5. Full-load zero-extraction throttle flow, (B4) × (B2) $= 1.027 \times 46{,}400 =$ (lb/hr) 47,650
6. Plot as point *1* in Fig. 8

Step C—Find half-load zero-extraction throttle flow (point 2, Fig. 8)

1. Half-load steam-rate correction for extraction turbine, (Table 1*b*) × (Table 1*c*) × (Fig. 5) × (Fig. 6) $= 1.08 \times 1.068 \times 1.00 \times 1.011 = 1.166$
2. Half-load zero-extraction throttle flow, (C1) × ½ × (B2) $= 1.166 \times ½ \times 46{,}400 =$ (lb/hr) 27,030
3. Plot as point *2*, Fig. 8; draw straight line from *1* to *2*

Step D—Find maximum required throttle flow (point 3, Fig. 8)

1. Maximum extraction flow, lb per hr 60,000
2. Max required throttle flow, (B5) + (A4) × (D1) = $47{,}650 + 0.803 \times 60{,}000$; (lb/hr) 95,830
3. Plot as point 3 in Fig. 8

Step E—Draw constant-extraction-flow Willans Lines

1. Throttle flow, lb per hr = (B5) + extraction factor × extraction flow $= 47{,}650 + 0.803 \times$ extraction flow
   55,680 at 10,000; 63,710 at 20,000; 71,740 at 30,000; 79,770 at 40,000; 87,800 at 50,000; 95,830 at 60,000
2. Plot as points at full rated load on Fig. 8
3. Draw straight lines from full load to half load through these points parallel to *1*—*2*

Step F—Minimum exhaust-end flow line

1. Cooling-steam flow to nearest 100 lb per hr from Fig. 7 5300
2. Plot points on constant-extraction-flow line where (throttle flow) — (extraction flow) = cooling-steam flow. For this turbine (throttle flow — extraction flow) exceeds the required cooling-steam flow, that is, minimum-exhaust-end flow line lies below ½ load
3. Draw straight line through the points between ½-load line and max-throttle-flow line

Problem 1*b*—Fig. 8

Same conditions as Problem 1*a* except that turbine has 80% maximum load at zero extraction flow and rated extraction pressure

Steps A through C— same as 1*a*

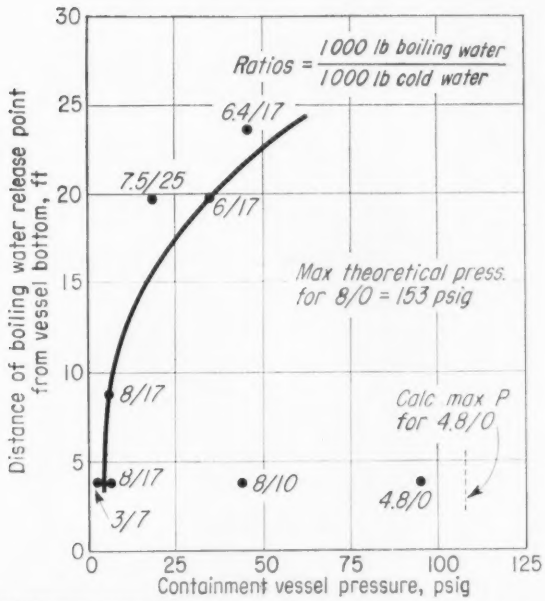
Step D'—Maximum required throttle flow

1. Locate points *1'* and *2'* by dropping throttle flow line *1*-*2* by 1½% at *1* and 2½% at *2*
2. Locate *3'* by method of step D

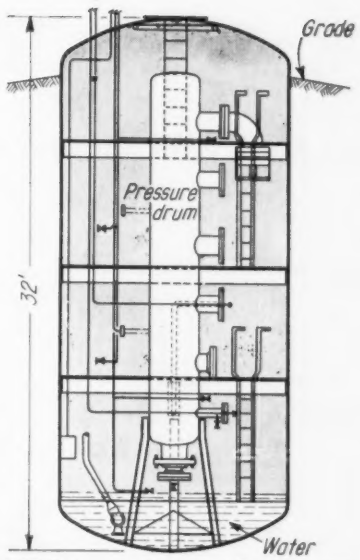
Steps E' and F'—same as steps E and F

Step G—Maximum flow to exhaust line

1. Draw a straight line through point *1'* and the points on constant-extraction-flow lines where throttle flow equals (point-1' flow) + (extraction flow)



WIDENING DISTANCE between flashing hot-water discharge point and cold-water level in tank bottom raises flash-steam pressure



PRESSURE DRUM in containment tank discharges pressurized hot water when explosion diaphragm at elbow exit is punctured

Tests point way to cutting containment costs

Full-scale tests measure the pressure reduction of flashed steam by making it flow into nearby pool of cold water

At a meeting in Chicago, Ill., on Oct 13th, 1959, Alf Kolflat, Senior Partner of Sargent and Lundy, reported on the tests they are running to study effects of cold water on reducing flash steam pressures. These tests aim to cut the costs of containment vessels for nuclear-power plants.

Test setup. A drum, 42 in. in dia and 23-ft long, stands inside a containment shell, 14 ft in dia and 32-ft high, almost completely buried. Drum is designed for 700 psig and the shell for 100 psig.

Steam from the nearby Hennepin Station of Illinois Power Company heated 8000 lb of water in the drum to boiling at 600 psig. All of the openings in the drum were blanked off except one fitted with an elbow holding an explosion diaphragm. A steam-operated trigger broke the diaphragm to release the flashing saturated water which fell into a pool of water in the bottom of the shell.

Test results. In the first test 3000 lb of boiling water was discharged through the bottom nozzle, 1-ft above the pool of 7000 lb of cold water in the shell bottom. Hot water discharged completely in 2½ sec but the shell pressure only rose to 4 psig. Theoretical pressure without cooling was 74 psig. This test is plotted as point 3/7 on the graph, shown at left, above.

In next test 8000 lb of boiling water was discharged from the same nozzle into 17,000 lb of cold water. The 5-sec discharge raised flash-steam pressure to only about 5 psig in shell, point 8/7 at 4-ft elevation.

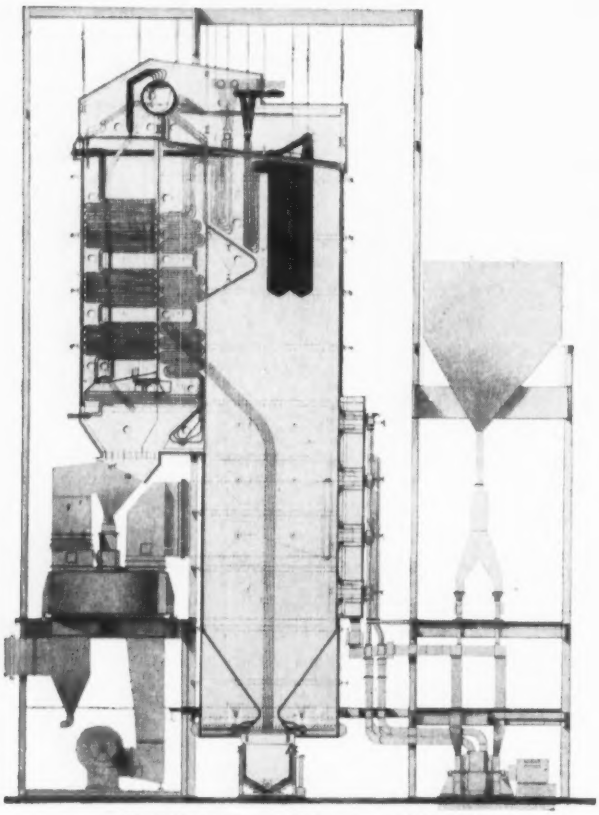
As the cold water was reduced in later tests, shell pressure rose. At zero-lb cold water and 4800-lb hot water the pressure rose to 95 psig compared to a theoretical expected pressure of 108 psig. Heat transfer to the shell wall and other surfaces kept pressure down. But the effective pressure reduction by the cold water was shown to great advantage.

Graph shows the results for different hot-cold water ratios and distances from discharge point to cold-water pool. Increasing distances raise final shell steam pressure.

Future tests. In a planned series of new tests a thin-wall pressure vessel will be surrounded by a second tank holding cooling water. Pressure vessel will rupture from overpressure at some undetermined point and discharge directly into the cooling water.

Savings. Estimates were made for redesigning the EBWR boiling-water reactor at Argonne National Lab to take advantage of cooling water for pressure reduction. Total plant costs would be reduced by about $450,000 or 10% of total. For larger plants, total plant investment would be cut by about 5%. Eight manufacturers and contractors and 11 utilities support these tests.

Are You Planning To Burn COAL ? OIL or GAS ?



950,000 lbs./hr., 1950 psig, 1000/1000F;
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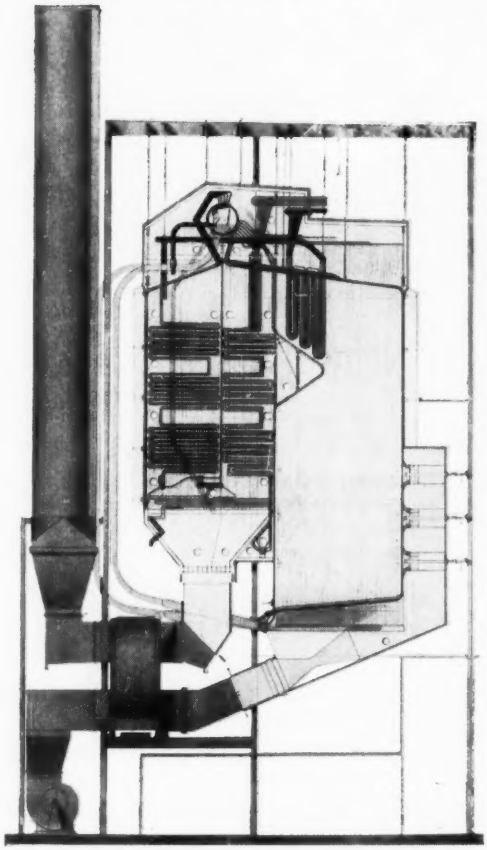

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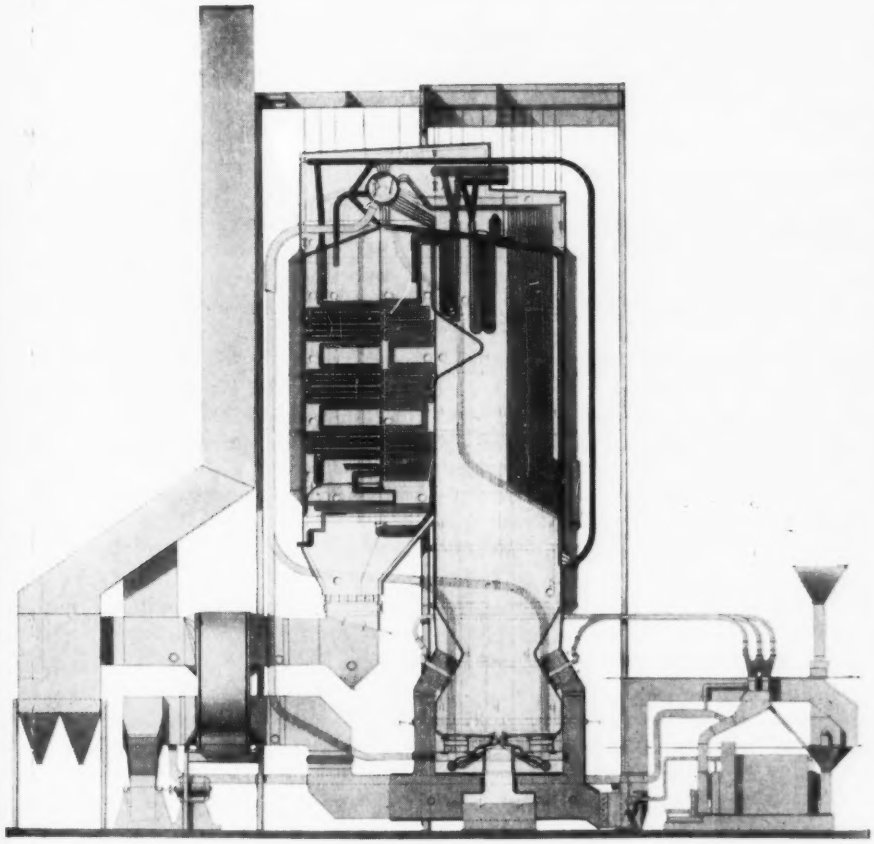

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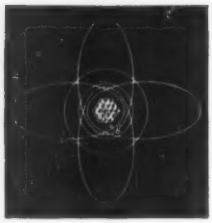


Nuclear notes

By B G A SKROTZKI, Associate Editor

Enriched nuclear fuel will be available in quantities to meet the most optimistic forecast for future demands, says John A McCone, Chairman of the USAEC. This can be done without affecting the weapons program or other essential defense needs. Also, the established price of enriched uranium fuel is not and never has been a subsidized price. The price reflects the full costs of production. No increases in the price schedule are expected, barring ucontrolled inflation and rising interest rates.

Liquid fluidized bed reactor (LFBR) will be developed by Nuclear Division of The Martin Company for the AEC under a 17-month contract costing $840,000. A critical experiment will be built in which a cylinder with a perforated plate near the bottom supports a mass of pea-sized slightly-enriched fuel pellets. The pellets support a chain reaction only when they are separated by a specific distance. The fluid coolant-moderator is forced through the loose pellet mass from the bottom making them slightly buoyant and separating them enough to establish a chain reaction. Abrasion effects on various types of fuel pleets with and without metal cladding will be studied.

Dresden Nuclear Power Station of the Commonwealth Edison Company went critical on October 15, 1959. The 180-mw plant, about 6 months ahead of the construction schedule, is now expected to go into full operation by mid 1960.

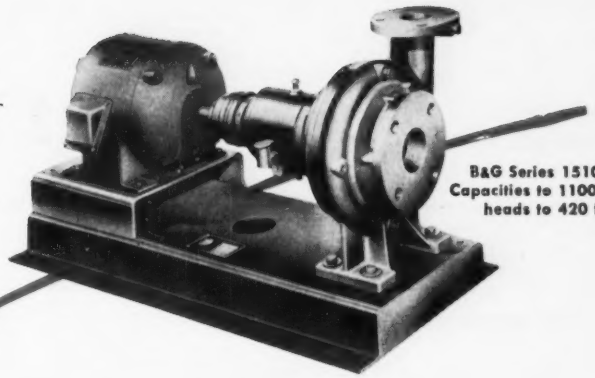
Revised specifications for the invitation to cooperatives and public power groups to build a small PWR plant have been announced by the AEC. The new plan now includes a fossil-fuel-fired superheater. Saturated steam output of the reactor remains unchanged but the heat input to superheater, type of fuel and rating of turbine-generator will be left to discretion of the proposer.

Processing spent fuels from privately- and publicly-owned reactors has been assigned to the Hanford, Oak Ridge, Savannah River and Idaho Falls operations offices of the AEC. The AEC has agreed to provide processing services until they become available from private sources. The four offices are ready to negotiate contracts with organizations owning reactors. Assignments have already been made for fuels from 17 power and experimental reactors already operating or under construction.

Process-steam reactors were the subject of a questionnaire distributed to 200 industry representatives by the AEC. The 65 replies received showed a preference for steam outputs from 100,000 to 250,000 lb per hr at pressures up to 600 psig. Most of the responders would use the reactor for normal steam supply with a conventional plant standing by for emergencies and peaks. Developing the reactors in cooperation with the AEC was preferred. The AEC is now working with the Department of the Interior in building a process heat reactor for distilling sea water on Point Loma, near San Diego, California.

Sea-water distillation plant mentioned above will use a 40-mwt, experimental, low-temperature process-heat reactor producing saturated steam at pressures from 5 to 175 psig, designed by the AEC. The U.S. Department of the Interior will build the water-conversion plant to produce at least 1 million gpd of fresh water. The reactor will be a PWR and the water plant will use a multi-stage flash distillation cycle. The reactor plant will cost about $4 million and the water plant about $2 million. Sargent & Lundy are doing the reactor, Fluor Corporation the water plant.

A GREAT LINE OF PUMPS ALL EQUIPPED WITH THE...



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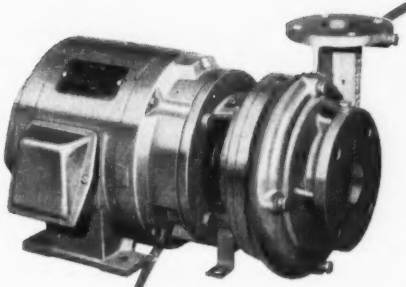
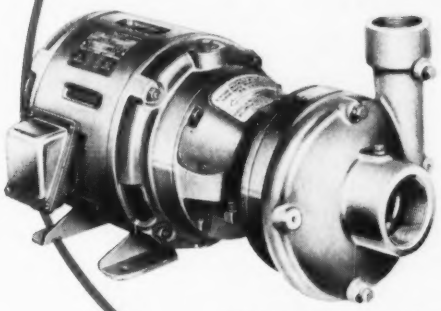
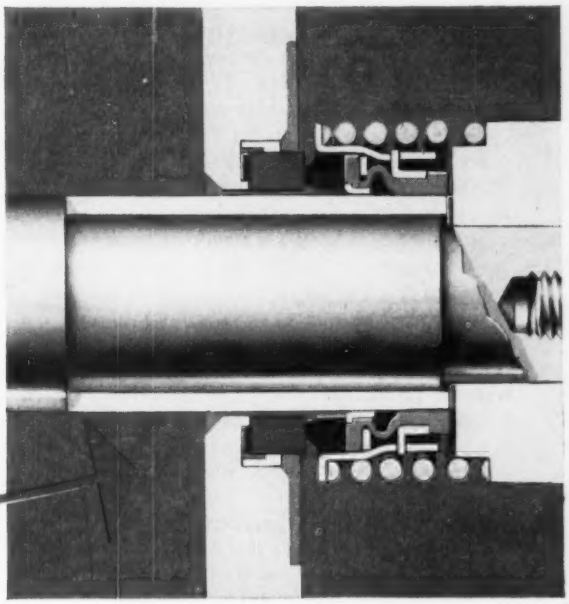


B&G Series 1531-B. Capacities to 1500 GPM, heads to 420 ft.



B&G Series 1522. Capacities to 150 GPM, heads to 115 ft.



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Reserved for your comment

BOB BELLAS, Associate Editor

Oh wad some power the giftie gie us . . .

I hope Messrs Pasell and Johnson aren't contemplating a trip out here to the Pacific Northwest because our unemployment problem is quite serious. *(A hard look at our power services led to big savings,* Sept 1959, p 83.) These fellows could create a lot of havoc in a short time.

Seriously, I did enjoy the article and appreciate learning how engineers analyze a problem such as this and come up with money-saving results. While it is regrettable that some employees were let out of a job, the article illustrated two important points: (1) much can be done to improve economical operation in many plants and (2) the operating engineer is not an indispensable man.

Taking note of point No. 2, it's obvious that today's operating engineer should avail himself of all the latest technical publications he can get. He should strive for the next higher grade of license, in areas where licenses are required, or in any case prepare himself to qualify for the next job up the ladder.

I have witnessed several situations in which a man had the qualifications and ability to raise his license but didn't bother because he was satisfied with his present job and its so-called security. In two of the situations the men lost their jobs; one in a plant that shifted to purchased steam, the other due to new management determined to cut out all deadwood.

Again, it was a very interesting and, I may add, amazing article. I didn't realize how new methods could replace manual labor and show such a profit. I'd like to see more articles in this vein.

TOM MULLIN, *Seattle, Wash.*

Of current interest

I've kept a rather complete set of tear sheets of POWER's *Electrical Fact File* and make good use of them. I see, too, that copies are read by each of our plant's electricians. What I particularly like about this series is the systematic probing beyond mere surface symptoms.

This characteristic was brought to light in our own plant only recently. For years we had been testing all feeder relays, carefully noting their tripping points. Where adjustment in operating speed was necessary a recalibration was made. The only check on the current transformer to which these relays were connected was a simple continuity test. This consisted of hooking up the ct secondary in series with a 100-w lamp, fed from the ungrounded side of a 120-v circuit. This test showed us that the secondary was not open. But—and here's where we goofed—it did not tell us if any turns were short circuited. We now run a simple impedance check and in the process have spotted several cts where the secondary was all or partially shorted.

This incident points up, in a small way, the importance of fresh thinking about many of our long-accepted operating procedures.

N SNOW, *Dallas, Texas*

The heat's on

I read with interest of the heat-pump installation in the Flick-Reedy Corp building *(Heat pump keeps plant all-electric,* June 1959, p 75).

I can read between the lines that the system's designer, in deciding to use air as a heat source in winter, had the usual problem of finding that his evaporators delivered the least heat when most needed—when ambient air temperature dropped to −10 F. Further, defrosting took heat not only to separate ice from the coils, but to melt the ice on the floor for disposal. Perhaps a heat source developed by us in the agricultural field could help future designers of heat-pump layouts.

Heat from the earth has been harvested to temper fresh-air supply to egg-producing hens by burying a pipe at a suitable level below the earth's surface and having a blower force ambient air through the pipe to the poultry house. In one instance, required air was 3000 cfm and some 300 ft of 24-in. corrugated culvert pipe was buried 8-ft deep for this purpose. At design temperature of −20 F after subzero weather, this pipe delivered air to the poultry house at 10 F, a free sensible-heat gain of 30 deg. It's obvious that this simple device can greatly assist the performance of the heat pump. While the evaporator loses capacity as temperature plunges, the "pipe in the ground" gains capacity. Since there is no specific humidity, defrosting problems are alleviated.

Earth over the pipe is exposed to the elements and every rain serves to regenerate the normal earth temperature around the pipe. A more sophisticated design, setting out a matrix of such pipes under a paved area where rain could not penetrate, could succeed during the cold winter months in permafrosting a large volume of earth that might well retain its frost until the hot summer months

circle 248 on Reader Service card, p 123 ►

3 NEW G-E MOTORS AND 42 QUALITY IMPROVEMENTS

A family appearance in power station motors and 42 basic design improvements are now available from General Electric. The three new enclosures shown here enable electric utilities to select power station motors with the same modern appearance. And all of these new motors contain the same advanced features, painstakingly engineered to meet electric utility standards of reliability.

Among the 42 quality improvements available on all G-E boiler feed pump motors, are:

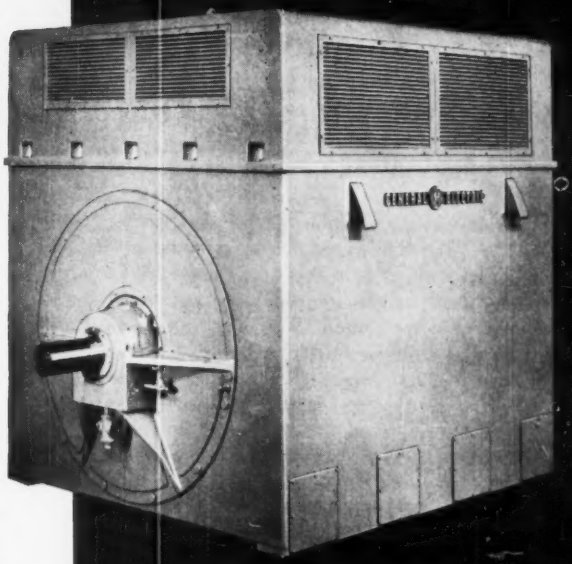
- **Polyseal* insulation system**—sealed against moisture; resists fly ash, most other abrasives.
- **Patented tying system**—heat hardened Permafil glass rovings hold end turns of form wound coils in a vise-like grip for maximum support.
- **Rugged frames**—provide added rigidity and strength required for power station service.
- **Extremely low noise level**—now possible with proven acoustic treatment.
- **Stator connections**—all brazed for more uniform strength, reliability.
- **Controlled slot wedging**—provides tight, stable fit, virtually eliminates coil looseness and resultant wear.

FOR THE COMPLETE STORY on G.E.'s 3 new power station motors and 42 quality improvements, contact your G-E Apparatus Sales engineer or write Section 884-3, General Electric Co., Schenectady 5, New York.

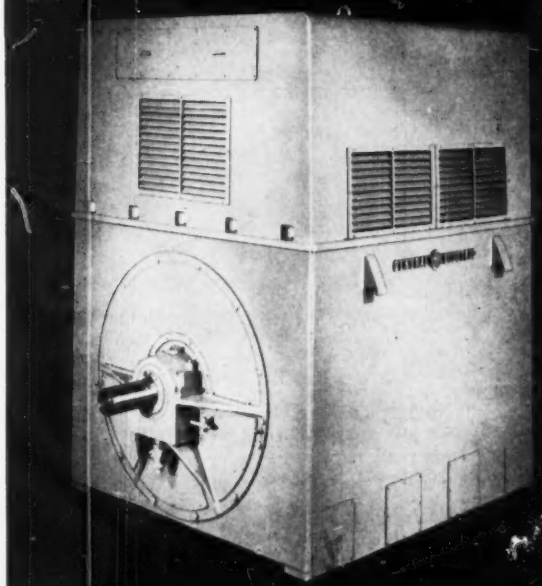
*Trademark of General Electric Co.

Progress Is Our Most Important Product

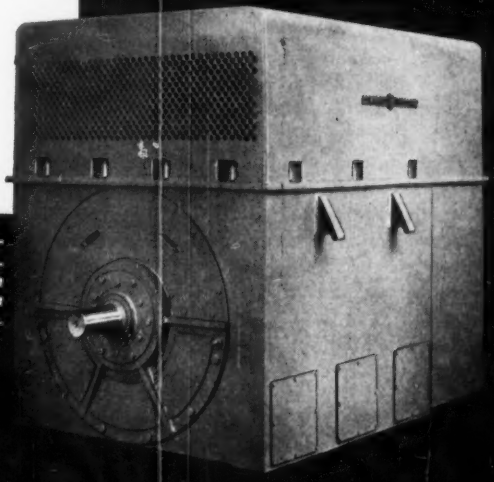
GENERAL ELECTRIC



BOILER FEED PUMP MOTORS—
Large 2-pole dripproof motors are acoustically treated for quiet operation—give long, reliable service.



G-E WEATHER PROTECTED MOTORS—
give better protection against rain, snow—even hurricanes—exceed NEMA Type II definition.



G-E TUBE-COOLED TEFC MOTORS—
are designed for easy disassembly, maintenance and inspection; computers select optimum number, size and arrangement of tubes for most effective ventilation.

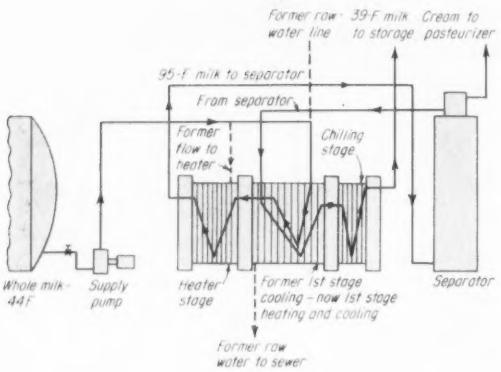
another G-E PROJECT '8000' development

PROJECT '8000'—
a major General Electric program of research, product redesign, advanced manufacturing and improved customer service on a-c motors 150- to 6000-hp.

when it could condition air for the reverse cycle.

I suggest that steel fabricators could profitably undertake research in this area. Extended surfaces could greatly increase the performance of such pipe pound for pound. Too, since air is used directly none of the disadvantages of disposal or change of state encountered in using other fluids with heat pumps will occur. I'd guess, also, that public utilities would find that base loads built up by fan motors forcing air through these underground conduits should prove to be an attractive addition to their market.

PAUL STURGES, *President*
Sturges Heat Recovery Inc,
Stone Ridge, N. Y.



. . . Reading Paul M Sturges' article, *Why waste heat,* (March 1959, p 89) made me think that perhaps our scheme to save Btu's might be of benefit to other readers.

Part of our process requires daily separation of up to half a million lb of whole milk at the rate of 50 lb per hr. Milk is received at about 44 F.

Former procedure was to heat it with hot water to 95 F for separating. Separated milk was cooled, first by well water at 50 F, then with chilled water at 35 F. This brought milk's temperature down to about 40 F before it went to storage tanks.

Present scheme, in effect, shifts Btu's back and forth. Where we formerly used cold raw water (at a rate of 100 gpm) to cool the separated milk we now counterflow cold whole milk and warm separated milk. Btu exchange raises whole-milk temperature to about 80 F which means that little more steam is needed in the heater stage to bring the whole milk up to the needed 95 F.

Arrangement gives us a saving of about 1.8-million Btu per hr which is equivalent to 17 gal of No. 6 fuel oil, assuming a 70% delivered efficiency of steam.

Incoming cold whole milk does a better job of cooling outgoing separated milk for two reasons: (1) Incoming milk is six deg cooler than raw water formerly used. (2) Since milk goes through both sides of the exchanger both sides are cleaned daily. We formerly cleaned the raw-water side only when decreasing cooling efficiency forced us to.

Sketch, left, shows whole- and separated-milk flow through the plate type exchanger, with dotted lines showing former raw-water flow. Existing hot- and chilled-water lines were omitted in the interest of clarity. Note how few piping changes were needed to accomplish so much saving.

MARTIN HUIKKO, *Chief Engineer*
First District Assn
Litchfield, Minn.

It's only money

I'd like to comment on the "parallel problems" in Mr Karassik's article to show how a major portion of the capital savings could be realized without jeopardizing unit reliability. *(Selecting pressure rating for closed feedwater heaters,* Sept 1959, p 71.)

Choice of feedwater heaters and valve design pressure appears to be a point of expensive contention. This is true, especially in valves, when one considers the staggering cost of cumulative safety margins. Article states elimination of heater isolation and bypass valves resulted in $20- to $25,000 capital savings. Would it not be sounder logic to investigate, eliminating some of the abundant safety margins, rather than expose utilities to $2000 to $3000 per day outage charges?

All too often the design engineer: (1) assumes the pessimistic attitude when choosing his design conditions (2) limits velocities in valves to pipeline velocity (40 to 50% of manufacturer's recommendation) (3) accepts B16.5 with its low allowable stresses and 50% shape factor as gospel and (4) chooses oversized and extra-thick-walled valves. For most feed systems, except those for boilers in the 2000-psi class and up, 900-psi valves one or two sizes under pipe size would be adequate and capital costs would be cut 60 to 70%. In the case of the 66-mw station mentioned, capital costs would drop from $20- to $25,000 to $6000 to $7500. Couple this reduction with the savings in valves and pipe using "3-way" globe valves, and capital investment for heater valves becomes dwarfed by coal costs of an emergency 2- or 3-day outage. If even Mr Karassik's correspondent acknowledges that, at worst, the valves will operate satisfactorily for a "few openings and closings," a plant operator can certainly look forward to at least short-time heater reliability in place of several expensive unit shutdowns.

GEORGE C WHEELER JR
Sales Manager, Steam Utilities Div
The Chapman Valve Manufacturing Co

Maintenance and Steam Traps

. . . there's a relationship that goes far beyond trap maintenance alone

Good traps and good trapping have a greater effect on your maintenance costs than does trap maintenance itself. By that we mean that the right traps, properly selected and installed, and with the benefits of a preventive maintenance program, will save far more maintenance dollars than they will cost.

Under the pressure of spiralling maintenance costs, this thought becomes mighty important. Let's take a look at what it involves:

Proper Selection of Steam Traps

1. Be sure it's the right type of trap.

2. Be sure it's sized right and is for the correct operating pressure.

3. Be sure it's first rate in design and construction.

Proper Installation of Steam Traps

1. Install them so they are accessible for inspection and maintenance.

2. Install a test valve.

3. Use a union or unions.

4. Use a shutoff valve or valves.

5. Use a strainer ahead of the trap if dirt conditions are bad.

6. Use a by-pass only where continuity of service is imperative.

7. Standardize inlet and outlet connections.

Preventive Maintenance Program

1. Test trap regularly for proper operation. (Trap size, operating pressure and importance determine frequency.)

2. Inspect internal mechanism at least once a year.

You Get Indirect Benefits As Well

The direct benefits of the plan outlined are pretty obvious — good traps, properly selected, require less maintenance . . . testing and inspection prevents troubles that lead to maintenance.

However, this plan provides indirect benefits which reduce maintenance in other parts of the plant as well:

Good traps save steam and reduce the load (and consequently maintenance) on fuel handling and burning equipment and on ash handling equipment.

Good traps protect the system by eliminating water hammer and preventing the damage it can do.

Good traps discharge carbon dioxide before it can go into solution to form corrosive carbonic acid — less corrosion, less maintenance.

Good traps increase production to reduce the length of time equipment must operate or reduce the amount of equipment needed . . . either way maintenance is reduced.

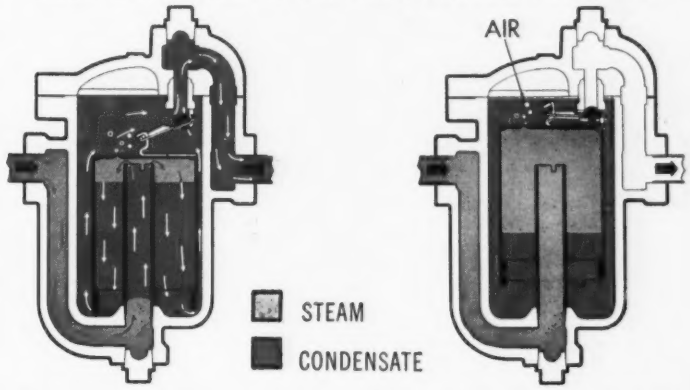
How to Go About It (The Sales Pitch)

We admit we're prejudiced, but we don't think there is any better way to select steam traps than with the help of the 44 page Armstrong Steam Trap Book. Here in a single source is specific data on the selection and sizing of traps, how to install them for best results, and how to maintain them most economically.

The Steam Trap Book will also give you full information on the design and construction of Armstrong Inverted Bucket Steam Traps that offer these important maintenance-reducing advantages:

1. Armstrong Traps are dependable.

HERE'S THE STEAM TRAP DESIGN THAT CAN REDUCE YOUR MAINTENANCE PROBLEMS



Trap open. Condensate entering trap has caused bucket to lose buoyancy. Weight of bucket times leverage pulls valve open. Air is discharged along with condensate.

Trap closed. Steam has floated inverted bucket; valve is held tightly closed by system pressure. Air entering trap passes through bucket vent and accumulates at top of trap.

2. Armstrong Traps require no adjustments — go from full load to zero load automatically.

3. Armstrong Traps are self-scrubbing—ordinary dirt conditions can't hurt them.

4. Armstrong Traps have long-life parts — valve and seat are heat treated chrome steel — lever assembly and bucket are stainless steel.

5. Armstrong Traps have water sealed valves to minimize wire drawing and erosion.

Ask for your copy of the Steam Trap Book—there is no obligation. Then test Armstrong Trapping. If you are not completely satisfied with the results, you can return the traps for a full refund of the purchase price. You can't lose much that way. Call your local Armstrong Representative or Distributor, or write

Armstrong Machine Works
8126 Maple Street
Three Rivers, Michigan

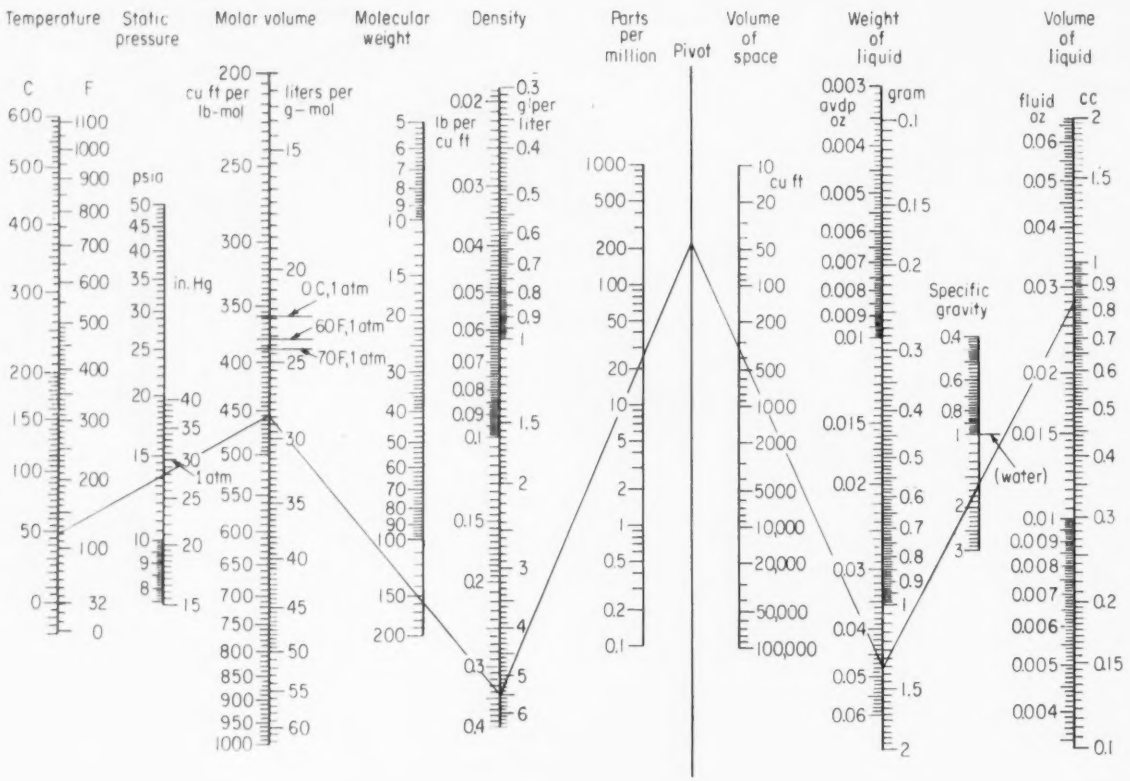
ARMSTRONG STEAM TRAPS

"See our catalog in Sweet's Plant Engineering File"

For more facts circle 249 on Reader Service card, p 123

Power's data sheet

NO. 328



Vapor concentrations in in-plant atmosphere

Frequently chemicals and solvents are used in areas with limited ventilation. In such cases vapor concentrations should be calculated and this information related to maximum allowable concentration for toxic vapor. *Maximum allowable concentration* is a term used in industrial hygiene and is based on an 8-hr working day in a given atmosphere. However, it is wise when working with toxic materials such as degreasing agents to be certain vapor concentrations will not reach short-time amounts which may cause ill effects.

Nomograph provides a simplified way to determine vapor concentrations for liquids under various conditions of temperature and pressure in work areas ranging in size from ten to 100,000 cu ft.

Relationship between concentrations of vapor and volume of the space is $W = (A \times 10^{-6})\ (XD)$, where W = weight of vapor in space, lb; A = vapor concentration, ppm; X = space volume, cu ft; D = vapor density, lb per cu ft. W also = weight of evaporated liquid.

Nomograph is extended to provide volume of liquid evaporated, V_L, by the formula $V_L = W/G$, where G = specific gravity of liquid.

Example: What volume of carbon tetrachloride must evaporate from degreasing tank into work space of 350 cu ft to reach maximum allowable concentration of 25 ppm at 120 F and 28.0 in. Hg. Molecular weight of CCl_4 = 154.84; specific gravity CCl_4 = 1.594.

Solution: Draw five lines as follows: (1) From 120 F on temperature scale through 28.0-in. Hg on pressure scale to molar-volume scale. (2) From molar-volume intercept through 154 on molecular-weight scale to density scale. (3) From density-scale intercept through 25 on ppm scale to pivot. (4) From pivot intercept through 350 on volume-of-space scale to weight-of-liquid scale. At this point intercept reads 0.0476 oz or 1.35 grams. (5) From weight-scale intercept through 1.59 on specific-gravity scale to volume-of-liquid scale. Desired result is 0.0286 fl oz or 0.846 cc.—M H Green, *Philadelphia, Pa.*

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COPPUS BLUE RIBBON PRODUCTS

Coppus Horizontal Steam Turbine

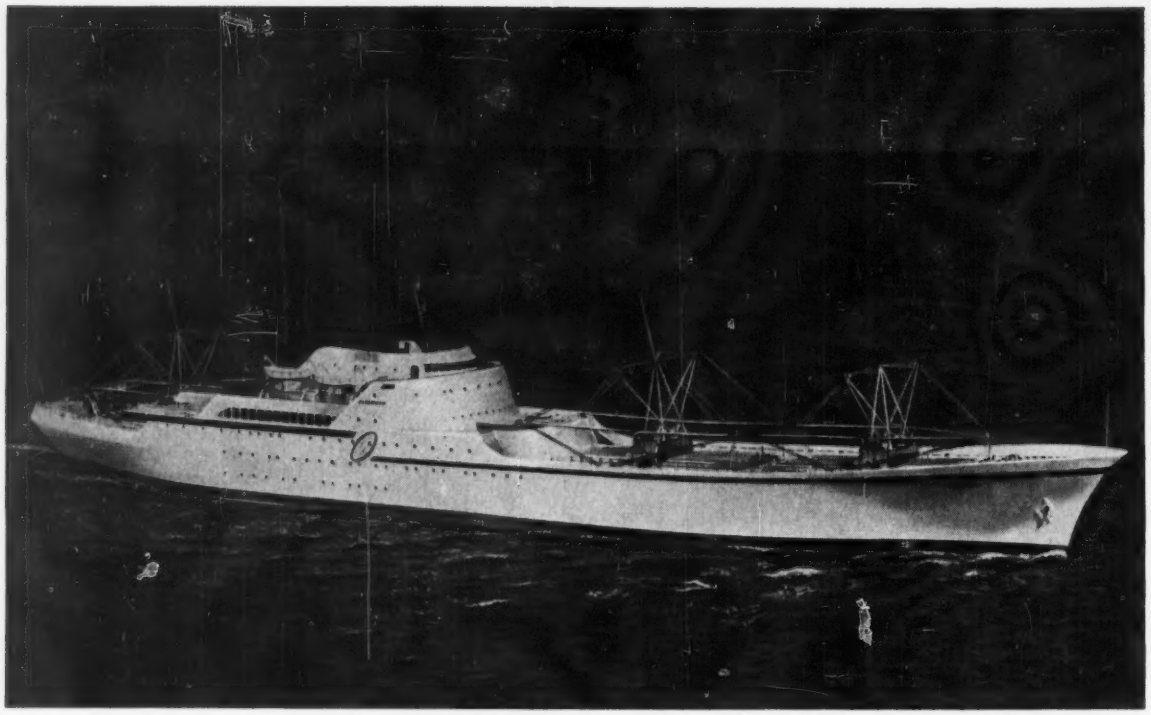
NEW RUGGED DESIGN—BLUE RIBBON RELIABILITY!
Here's a new dimension in turbine performance! Coppus brings you a new rugged stability of design . . . a new measure of reliability in a complete range of power-packed turbines, from 1 HP to 250 HP — marked with the Blue Ribbon only after each is precision made . . . precision tested. Performance features like these assure you Blue Ribbon Reliability —

A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION. 172 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

For more facts circle 250 on Reader Service card, p 123

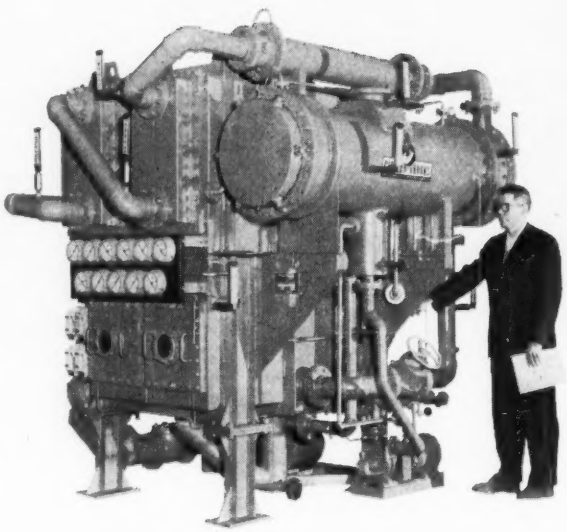


When America's First Nuclear-Powered Passenger Cargo Ship Goes to Sea...

BRIDGEPORT EVAPORATOR TUBES WILL BE ABOARD

The Nuclear Ship, *Savannah*, first of America's nuclear-powered merchant ships, now under construction at New York Shipbuilding Corporation, will be the first sea-going example of atoms for peace in the world.

She will embody the latest in nuclear design, technology and equipment. Part of *Savannah*'s modern equipment will be Cleaver-Brooks Flash Evaporators with their Bridgeport 90-10 Cupro-Nickel tubes. These evaporators combine fast evaporation, low rate of scale formation, simplicity of operation, and low installation and operating costs. Their uninterrupted service depends, in large measure, on the quality of the evaporators' tubes while meeting highly varied "world-wide" corrosive media.



Bridgeport 90-10 Cupro-Nickel tubes have an excellent operating record in ship and shore installations . . . a record based on nearly a century of progress in the manufacture of condenser and heat exchanger tube of a wide range of alloys.

Whatever your needs – ashore or at sea; atomic or more conventional, new construction or retubing – you'll find that they will be completely fulfilled by Bridgeport's Condenser and Heat Exchanger Tubes. And Bridgeport's Technical Service Staff is always ready to assist you in every way. Call your nearest Bridgeport Sales Office, or write for a copy of the Bridgeport Condenser Tube Handbook, Dept. 5412.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Conn. • Sales Offices in Principal Cities

*Specialists in Metals from **A**luminum to **Z**irconium*

For more facts circle 251 on Reader Service card, p 123

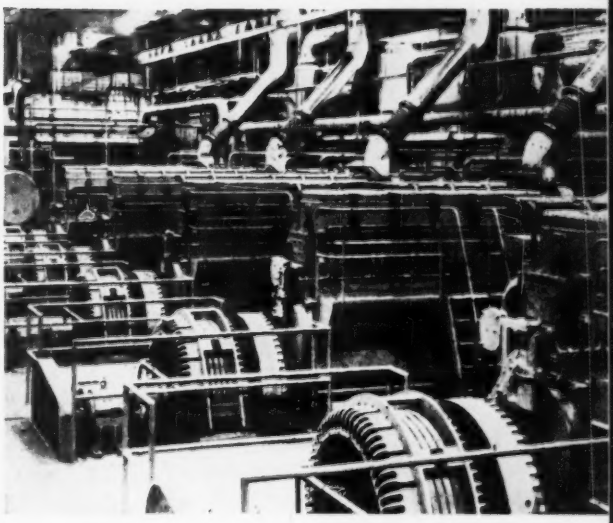
(official U.S. Air Force photo)

NORDBERG ENGINES help power SAGE System Direction Centers of the Air Defense Command

"Master-minding" the tactical operation of U.S. Air Force interceptors like this F-102 jet is an amazing electronic air defense system called SAGE . . . *Semi-Automatic Ground Environment.* By analyzing a variety of air surveillance information which is received from a vast network of facilities and fed into electronic digital computers located at its Direction Centers, the SAGE System computes the speed, altitude, and direction of planes in flight to facilitate identification. A picture of the air and defense situation is displayed so clearly that Air Force personnel can quickly decide when and where to intercept, should aircraft be identified as suspect. The system also monitors the deployment of selected air defense weapons.

The Direction Center computing and display equipment relies on station-generated electric power. To help assure adequate power at all times, Nordberg Diesels have been installed in several Direction Centers.

Nordberg Mfg. Co., Milwaukee 1, Wisconsin



Nordberg four-cycle diesels installed in one of the SAGE system centers, generating electric power for the electronic computers, communications equipment, etc. Each of the Nordberg supercharged 6-cylinder engines is rated 930 hp at 450 rpm and is monitored electronically.

NORDBERG

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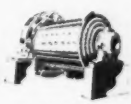
P658

SYMONS® CRUSHERS AND SCREENS

MINE HOISTS



GRINDING MILLS—KILNS AND PROCESS MACHINERY

RAILWAY MAINTENANCE EQUIPMENT

NORDBERG MACHINERY

ATLANTA • CLEVELAND • DALLAS • DULUTH • HOUSTON • KANSAS CITY • MINNEAPOLIS • NEW ORLEANS • NEW YORK • ST. LOUIS
SAN FRANCISCO • TAMPA • WASHINGTON • TORONTO • VANCOUVER • JOHANNESBURG • LONDON • MEXICO, D. F.

For more facts circle 252 on Reader Service card, p 123

Refractory insulating concrete stops stack corrosion

This gun-applied lining of refractory insulating concrete bonded with LUMNITE calcium-aluminate cement is providing dependable protection to stacks at United Illuminating Company, New Haven, Conn. Such linings resist corrosive action of flue-gas condensate forming on stack surfaces.

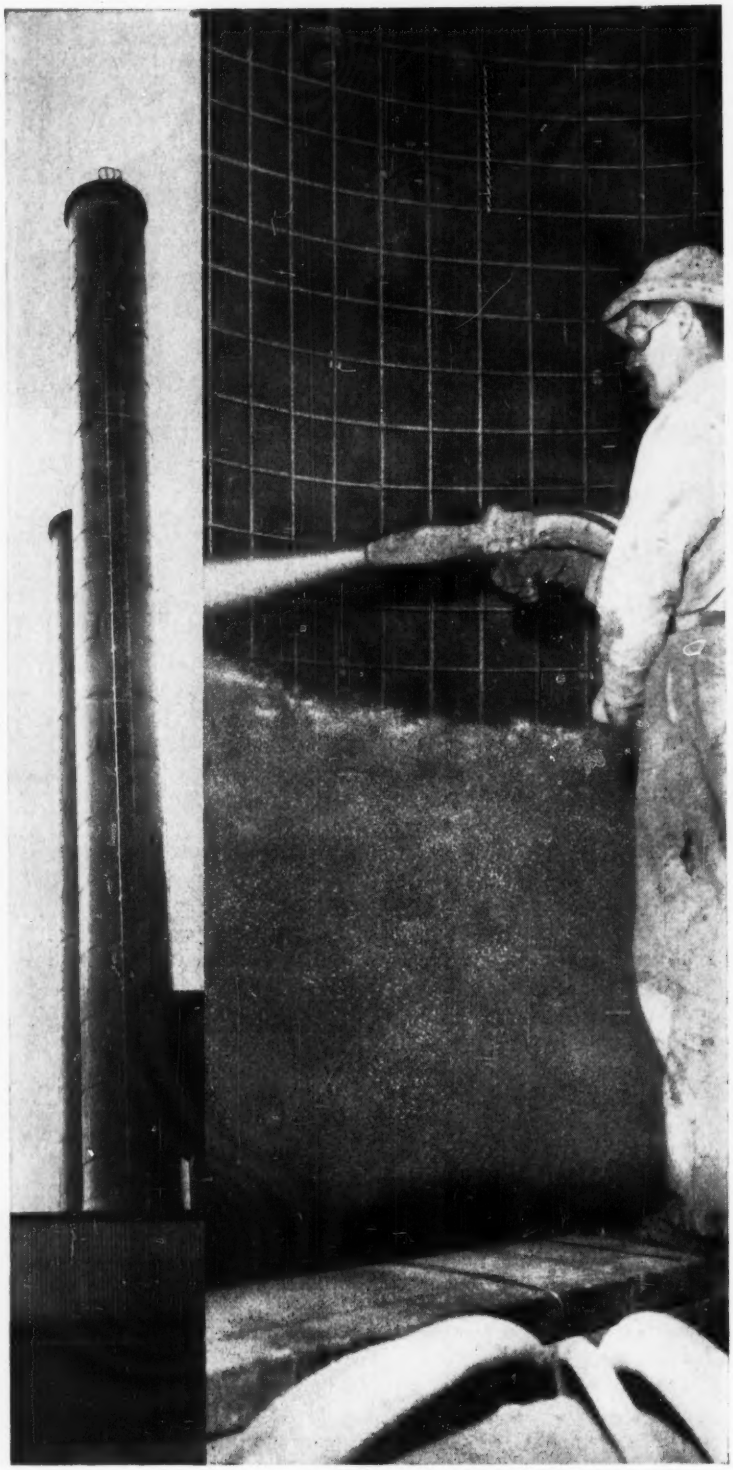
Furthermore, the concrete retains high strength under continuous exposure to heat as well as frequent heating-cooling cycles.

Installation is fast, easy, economical. Linings can be cast in place, plastered or "gunited." Service strength is reached in 24 hours.

For added convenience and economy, there are castables made with LUMNITE cement – packaged mixtures ready for use with just the addition of water. They're available from leading manufacturers of refractories.

For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

"USS," "Atlas" and "Lumnite" are registered trademarks.



Gunite Contractor: Pressure Concrete Co., Newark, N. J.

Universal Atlas Cement
Division of
United States Steel

L-194

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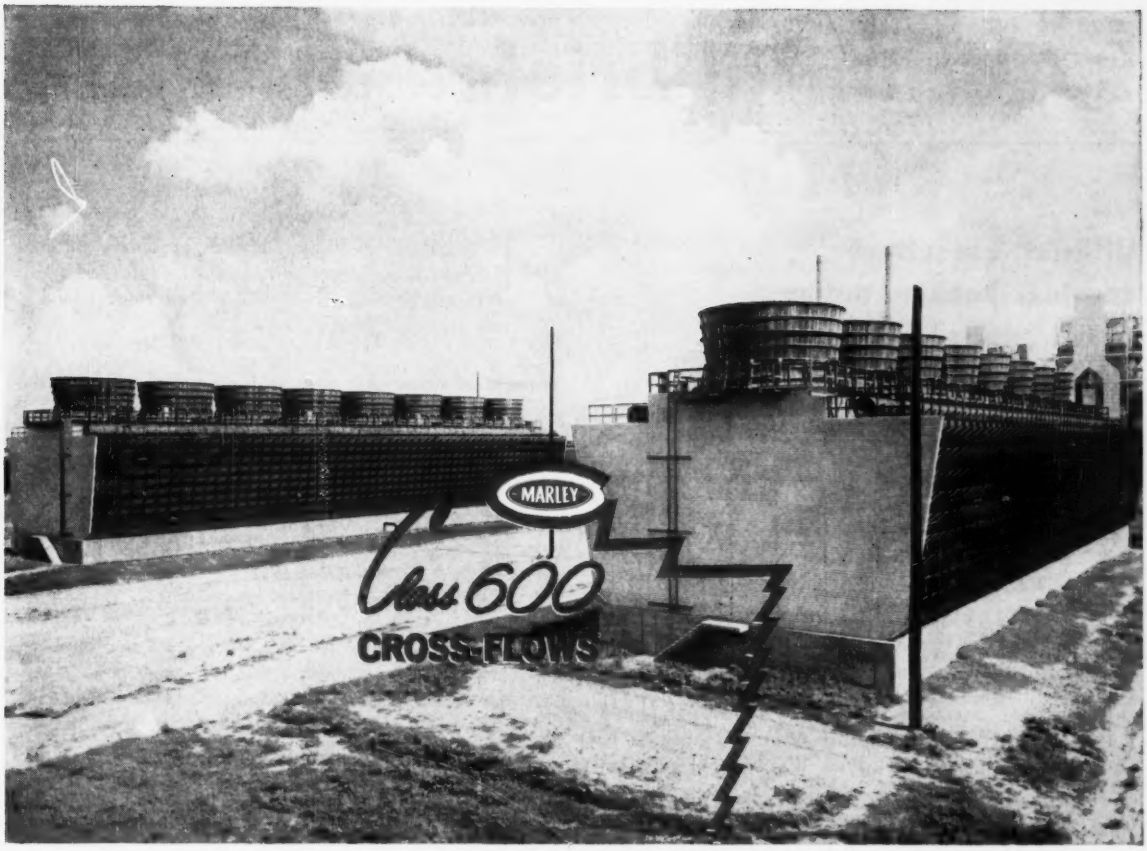


IN THE

100,000-GPM Bracket

When cold water requirements reach six-figure proportions, plant surveys suggest that selection of Marley Class 600 cooling towers is becoming a custom. The reason is "economic amplification" . . . as physical structure enlarges, so do Class 600's tangible and intangible advantages become progressively more important.

Consider the years that Class 600 structure adds to amortization period. Engineered for inherent durability, it has the added years-spanning protection of inert materials used at critical points throughout.

Class 600's longitudinally manifolded end-inlet distribution provides economy that increases with every foot of tower length.

Multiplied by the number of fan cells, the plus value of Marley engineered-for-the-job mechanical equipment and vibration-free fans is most imposing.

Marley's development of specialized equipment to facilitate service operations assumes realistic proportions when days (rather than hours) are conserved.

Performance? It is generally accepted as an established fact that a Marley Class 600 Cross-Flow tower will meet or exceed specified performance. Results of consecutive tests published annually emphasize the validity of this conclusion.

These are only part of an impressive list of factors that qualify Class 600 towers for highest standing in the largest capacity field. And every one is prominently present in *every* Marley Cross-Flow, whether it be a one-, four- or forty-cell tower.

THE MARLEY COMPANY MARLEY KANSAS CITY, MISSOURI

For more facts circle 254 on Reader Service card, p 123

Technical briefs . . . Latest engineering

Utilities, consultants consider peaking power to cut capital investment

Steam power plants for peaking service, *A R Lebailly, Sargent and Lundy Engineers*

Peaking problem forced upon large utilities today comes down to a question of capital investment vs revenue. Capital investment rises at about the same rate as system peak. Revenue increases only as fast as total energy sales. Spread between them is increasing, especially in the South.

This leads to consideration of low-cost higher-heat-rate units for peaking purposes as an integral part of an expansion program. For a peaking unit designed to operate only 1000 hr a year, an increase of 3000 Btu per kw means an annual fuel-cost increase of $0.60 per kw or, when it is capitalized, $4.00 per installed kw.

An installed-cost study illustrates capital-investment savings possible in four cycles, each one of 100,000-kw capability. Reductions up to $20 per kw are indicated. This saving can be achieved and likely exceeded by the judicious choice of throttle pressures, condenser vacuum and cycle arrangement.

Where cooling water is scarce, consideration should be given to diesel-electric and gas-turbine generation. Increased heat rate may well be offset by lower installed cost, reduced maintenance and automatic operation. *ASME 59-PWR-8*

Peaking—a definition of the problem, *R W Dodson, Southwestern Electric Power Company*

When winter and summer peak loads were approximately equal, total peak generation was a reasonable percentage of total annual generation. Now, with summer peaks far exceeding winter peaks, especially in the South, the picture is very different. At Southwestern Electric Power the top 30% of peak occurs for only 14% of the time and contains only 2.9% of annual generation.

Ever-increasing costs reflected in new fuel contracts frequently make the latest most-efficient unit also the highest-fuel-cost unit. Its net energy cost may be the highest in the system. So newest unit is used for peaking service. This situation will continue until long-term fuel contracts are renegotiated for older units in the system.

It would be logical to design new capacity specifically for peaking service. Characteristics should include low initial cost, ability to start rapidly and frequently, and simple and automatic operation. Peaking units installed at older standby plants require only a minimum of additional operators rather than the complete staff required at a new station. *ASME 59-PWR-6*

Theory of economic selection of generating units, *K L Hicks, Sargent & Lundy Engineers*

System growth in the past has involved installation of the most efficient unit of the largest size justifiable. New units were base loaded. Improved technology and larger sizes continue to better efficiency but the rate of improvement is becoming less spectacular. Efficiency difference between new and older units is becoming less and less, leading to consideration of new peaking units.

It is quite possible that units of an intermediate size may be optimum for a particular new installation. If one assumes that heat-rate improvements vary inversely with installed cost, number of possibilities is very large. Normal process of comparing alternate plans becomes cumbersome.

Loading-triangle method is offered as a simplification of this evaluation process. It is a proportioning device dependent only upon total system capacity and capacity of the installed generating units. Successive solutions to the equations will produce "long-run" predictions of optimum sizes.

Several sample calculations are made to examine base-load and peaking-load units and to predict new requirements over a 10-year period. *AIEE 59-1177*

Fuels

Use of bench-scale tests to predict combustion perfomance of coals, *E A Zawadzki and F du Breuil, Bituminous Coal Research Inc*

Tests reveal that a reliable bench-scale procedure can be developed to evaluate various coals. This replaces costly and time-consuming full-scale equipment. A specially designed test furnace with 1-sq-ft grate area was used. Data obtained from this and other current bench-scale combustion tests were correlated with full-scale combustion test data.

Design of test furnace is reviewed. Test procedures and details of data-collecting methods are outlined. Of particular value is the ability of this test furnace to determine caking characteristics of coals tested. Previously, full-scale tests were required for this purpose. *ASME 59-FU-3*

The Power mine and coal for Montrose Station, *J R Jones, Peabody Coal Company*

Montrose Station of Kansas City Power and Light Company takes the entire output of Peabody's

Power strip operation. Currently, 500,000 tons are delivered annually for the first unit. When Unit 2 goes on the line, this figure will be a million tons.

Two seams are involved having varying sulfur content. The coals are handled separately at the mine and blended at the station to keep within contract maximum sulfur content of 6%.

Mine operation was specifically designed to serve a single utility customer. Equipment for mine operations and transportation is covered, giving experience with each item.

Laboratory facilities are maintained at the mine as well as the power plant to determine monthly penalty or bonus based on as-received Btu content and weighted sulfur content. *ASME 59-PWR-3*

Factors to consider in the use and application of industrial coals, *U B Yeager, Island Creek Coal Sales Company*

Evaluation of industrial coals solely on the basis of cost per million Btu can be very misleading. A wide variety of considerations have a far greater effect upon proper coal selection. The mere fact that newer equipment may be better able to handle and burn inferior coals should not be complete justification for their use.

In addition to accurate heating values of strictly representative samples, several other characteristics deserve attention. Among these are sulfur content, grindability, ease of handling, relative maintenance costs and ash content of each coal type.

Consideration of all pertinent factors will frequently show the added advantage of burning so-called "good" coals. *ASME 59-FU-2*

Testing

Fifteen years' experience employing simplified performance tests to follow plant efficiency, *F H Light, Philadelphia Electric Company*

The Philadelphia Electric Company has used simplified performance tests for 15 years. They are conducted to reveal changes in performance of unit components. Places where corrective action is needed are readily pinpointed.

Data collected and results calculated determine percent over established bogey. Required instrumentation added only 0.3% to cost of one 125-mw unit, and several side benefits result from these tests. Accuracy of control-room instruments is checked, young engineers are trained in techniques of testing and calculating results, improvements due to design changes during service life are analyzed.

Application of an automatic data-collecting system is being studied. This will provide accurate, permanent log sheets and permit a quick analysis of factors affecting overall performance. Savings potential in even a 0.5% improvement are sufficient to justify data-collecting system. *ASME 59-PWR-5*

Development of a power test code for steam turbines including a new procedure for simplified tests, *O D Whiddon, The Detroit Edison Company*

Power test code No. 6, *Steam turbines*, is currently being revised. This is the fourth revision since it was originally issued in 1915.

Recognizing the high cost ($50,000 to $75,000) and complexity of code acceptance tests, the committee plans to evolve a procedure for conducting simplified steam-turbine tests which can be used on a repetitive basis for checking turbine performance during the life of the machine.

To be useful, the simplified test must produce a substantial cost saving. At the same time it must maintain good test accuracy. One solution may lie in compromising the absolute accuracy somewhat and concentrating on maintaining relative accuracy. This would produce inexpensive but reliably accurate comparative tests on a repetitive basis. *ASME 59-PWR-7*

"Bench-mark" testing in industrial plants, *L J Brown, E I DuPont de Nemours and Company*

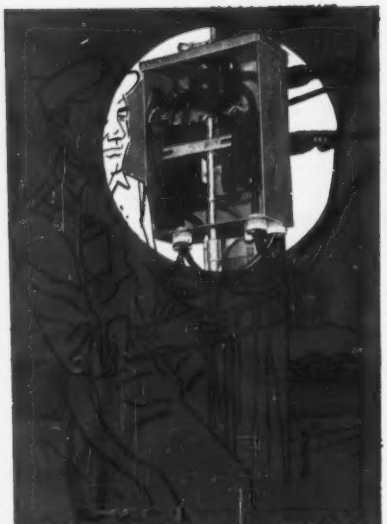
DuPont operates over 80 power plants of widely varying sizes, up to 250,000 lb per hr and 7500 kw. Strict ASME-code acceptance tests would cost as much as for a large utility installation. While reasonably close adherence to ASME test codes is attempted, various compromises have been economically necessary.

In acceptance testing, both owner and vendor recognize that a certain degree of accuracy is lost; larger tolerances are agreed upon. Calibrated operating instruments are usually used for test readings —it is less costly and future check tests can be made using the same instruments for comparative purposes. It is then possible to determine relative changes in performances even though absolute accuracy is not as high as theoretically possible.

Acceptance tests are regularly run on dust collectors, cooling towers, fans and pumps as well as boilers and turbine-generators.

Use of computers for periodic performance-test checks permits quick determination of results and rapid correction of faulty operating procedures or equipment. Losses resulting from reduced performance levels are minimized. *ASME 59-PWR-4*

continued



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Technical briefs

Begins on page 114

Performance of large water-wheel - generator pivoted - pad thrust bearing determined by tests under normal operating conditions, *R A Baudry, E C Kuhn and G D Cooper, Westinghouse Electric Corporation*

Physical size of large vertical-generator thrust bearings (84-in. dia) rules out shop testing, and lack of test data has made designers reluctant to increase unit loads. Now, field tests conducted at Coulee and Chief Joseph dams indicate higher loadings are permissible.

Data collected include actual thrust loads, hydrodynamic pressures in the oil film, oil-film thickness, starting and stopping characteristics. Contrary to common belief, it was found that oil film is maintained until machine is completely brought to rest, and metal-to-metal contact does not occur while stopping.

Immediately after stopping there is a rapidly diminishing concentration of load near the center of the pad. For this reason, among others, it is undesirable to restart a bearing immediately after shutdown.

These field tests assure satisfactory operation with higher unit loadings. They will make possible the higher-capacity thrust bearings required by the even-larger hydroelectric generators of the future. *AIEE 59-819*

To obtain complete text

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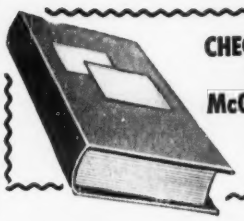
American Society of Mechanical Engineers (ASME). Contact ASME, 29 W 39th St, New York 18, New York.

American Institute of Electrical Engineers (AIEE). Contact AIEE, 33 W 39th St, New York 18, New York.

Growing ties between art and industry are emphasized by a recent exhibit of paintings on industrial and technical subjects at the Silvermine Guild of Artists, New Canaan, Conn.



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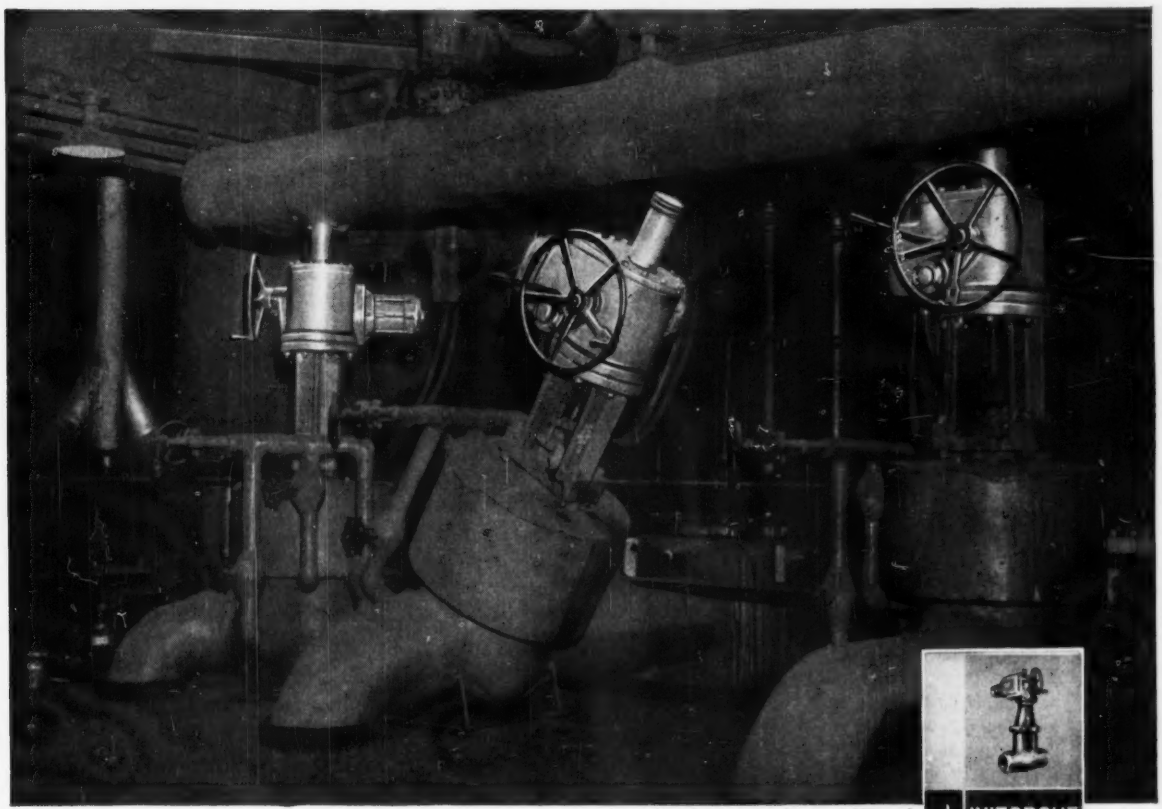

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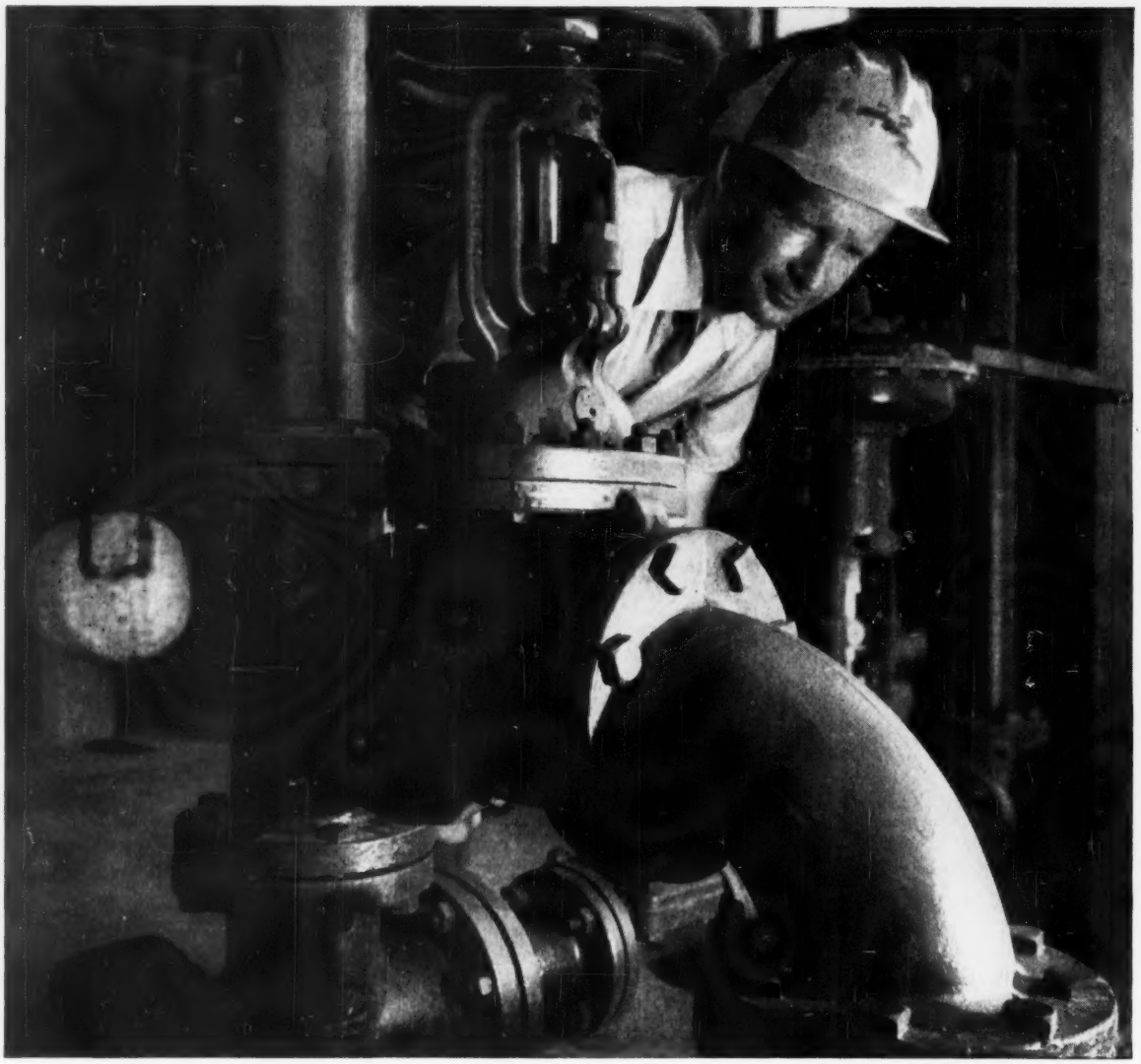

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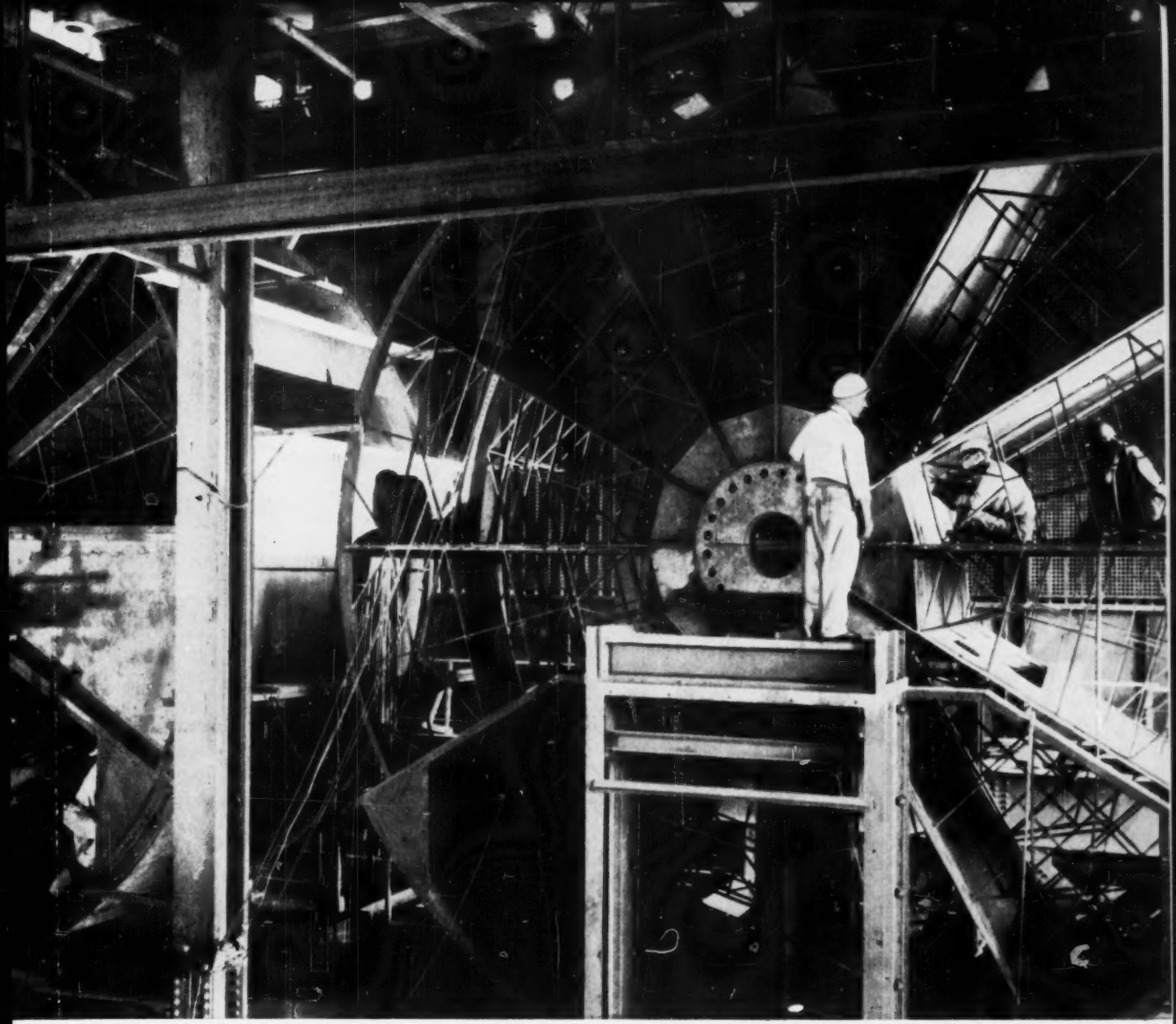

Two of the four Ljungstrom Air Preheaters under construction at Potomac Electric Power Co.'s Dickerson Power Plant, Dickerson, Md. Each pair of these Ljungstroms, with a combined heat exchange surface of 475,000 sq. ft., will serve one boiler, evaporating 1,300,000 lbs of steam/hr. The first 175,000 KW unit was placed in operation in June this year and a duplicate unit is now under construction.

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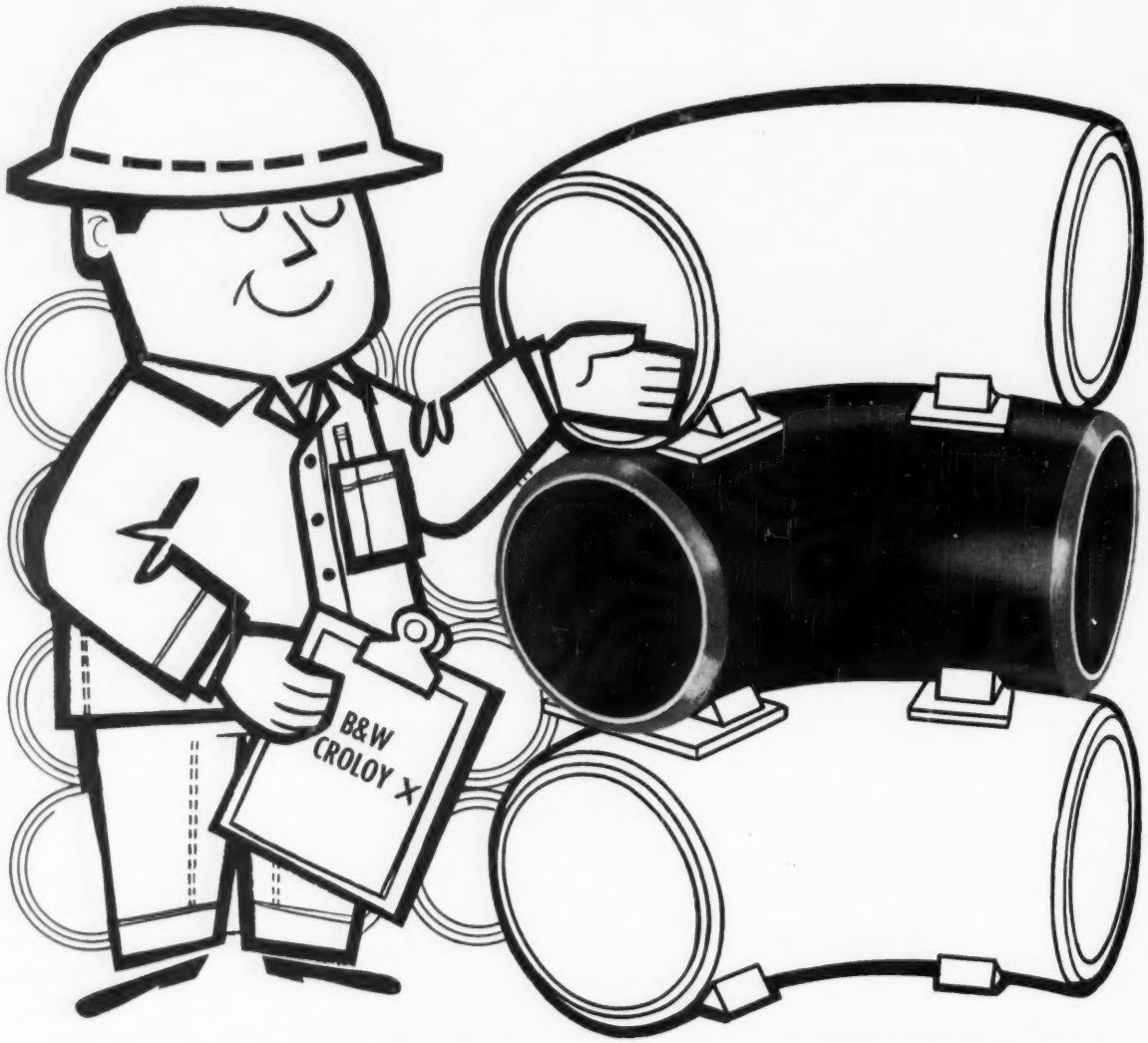

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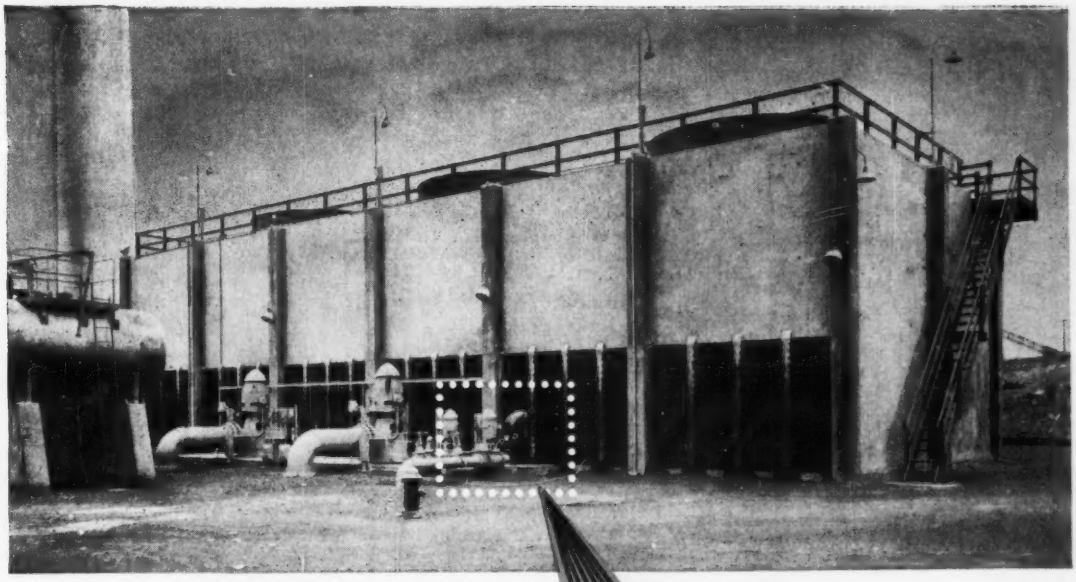

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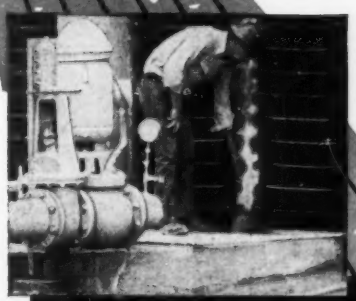

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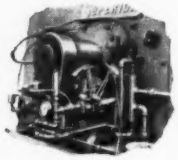

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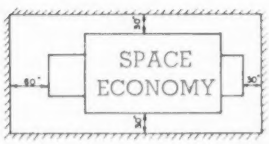

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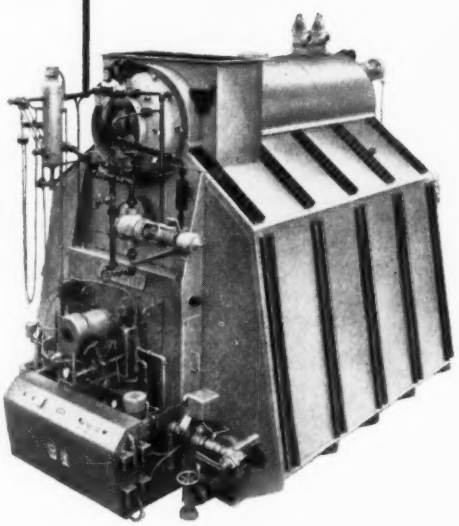

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102 **Two-pass boiler** for heating and power is topic of 4-p bulletin B-3232. Unit features wet-back construction, updraft gas passages, large furnace volume. Includes design details, spec sheets. The Titusville Iron Works Co

103 **Deaerating heaters,** spray type, are discussed in 8-p bulletin Wc-1010. Covers principles of deaeration, deaerator operation, standard designs available and accessory equipment. Graver Water Conditioning Co

104 **Power and heating boiler,** 3-pass with all-wet-back construction, is topic of new product bulletin B-3240. Includes specs. The Titusville Iron Works Company

105 **Heating units** with 800-, 1000- and 1260-Btu output are covered in three new-product spec sheets. Dimensional drawings and illustrations of floor-mounted and horizontally suspended units are given. Wanson Corp

106 **Radiant heaters** are covered in catalog GC-106. Features baseboard, wall-panel and ceiling-recessed glass and electric units, includes technical and descriptive info, specs. Berko Electric Manufacturing Corp

107 **Refrigeration systems** in modern gasoline plants are topic of 8-p bulletin 172. Clark Bros Co

108 **Absorption cold-generator** catalog shows absorption operational cycle in colored illustrations, hermetic-pump operation, other product features. Gives dimensions and specs. The Trane Co

109 **Carbon-odor filter** for air cleaning is described in 4-p bulletin 220. Gives engineering data on filter's initial resistance. American Air Filter Co, Inc

110 **Industrial fans** are presented in 28-p bulletin L-5. Includes rating tables giving volumes of delivered air, rpm, hp at various static pressures, outlet velocity and velocity pressures. Correction-ratio tables for deviations from standard atmospheric conditions at sea level are also given. Includes graphs, diagrams, dimensions and arrangements. Fuller Co, Lehigh Fan & Blower Div

111 **Mechanical dust collectors** and their recent improvements including new involute design are covered in 8-p bulletin 300. Research-Cottrell, Inc

METALS AND MATERIALS

112 **H-t high-stress superalloys** are topics of 8-p and 12-p bulletins. Describes alloys produced by vacuum-induction-melting process, lists chemical composition, physical constants. Tables and charts on mechanical properties, isostress curves are included. Kelsey-Hayes Co, Metals Div

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113 **Permanent magnets,** high-flux Alnico-V-7 type, are described in engineering bulletin 350. The Indiana Steel Products Company

114 **Rtv silicone-rubber compounds** are topic of 12-p bulletin CDS-170A. Info on product properties, suggestions for handling compounds, curing and viscosity characteristics and info on room temperature vulcanizing primers for bonding applications are given. General Electric Co

115 **Silicone rubber** for lead-wire insulation is topic of 4-p bulletin. General Electric Company

116 **Liquid formula** for use on electrical and electronic equipment is introduced in new brochure. Inhibitor displaces and seals out water and moisture, protects against corrosion, lubricates. Corrosion Reaction Consultants, Inc

COMPRESSORS AND ACCESSORIES

117 **Packaged air compressor** selection guide for small models is a 16-p booklet. Covers air-compression process. Ingersoll-Rand

118 **Centrifugal compressors** with capacities from 800 to 8000 cfm, pressures to 1000 psia are featured in 4-p bulletin P-12. Carrier Corp, Elliott Co Div

119 **Eliminating explosions** in compressor-starting air lines is topic of bulletin 173. Clark Bros Co

120 **Ac centrifugal compressors,** single-stage, are covered in 12-p bulletin 16B6048C. Pedestal-mounted, ball-bearing, bracket-mounted, pivoted-shoe-bearing models in wide volume range are described. Allis-Chalmers Manufacturing Company

121 **Compressors,** single-stage and 2-stage models, ranging from ½ to 15 hp with pressures from 80 to 250 psi are featured in 12-p bulletin SG-2. Photos, cutaways, specs included. Westinghouse Air Brake Company, Le Roi Div

MATERIALS HANDLING

122 **Self-locking fasteners** eliminate need for brackets and clips, come in one piece in forged, impact-extruded and aluminum alloy. Illustrated 15-p brochure describes entire line. Western Sky Industries

123 **Automatic coal conveyor** is described with specs in 4-p brochure. The Will-Burt Co

124 **Curve-crown pulley** with welded, all-steel construction is announced in new-product bulletin 558. Stephens-Adamson Mfg Co

ELECTRICAL GENERATION, TRANSFORMATION AND CONVERSION

125 **Electric generating plants** with gasoline and diesel-engine-driven generator sets are topic of new-product catalogs F-146, F-142-A. Range is to 170 kw (gasoline) and 230 kw (diesel). D W Onan & Sons, Inc

126 **Rectifiers** for load currents up to ten amp and 25- to 35 amp silicon-controlled models are topics of data sheets XSR-310 and XSR-350. International Rectifier Corp

continued

December 1959 issue

This card void after March 1, 1960

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PLANT EQUIPMENT in the news this month, starting on p 134

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26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
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NEW LITERATURE listed in this issue, starting on p 123A

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ADVERTISED PRODUCTS appearing throughout the issue

201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225
226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250
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NEW FREE LITERATURE continued ..... Circle key numbers, page 123, for your copies

127 **Silicon - rectifier** power supplies rated 40 to 60 kv, up to 700 ma dc for electrostatic-precipitation applications are subject of 4-p bulletin GEA-6854. General Electric Company

128 **Medium transformers,** open and sealed dry type, distribution equipment and integral distribution centers are described in 12-p bulletin. Firm's complete line is given. General Electric Co

129 **Transformers,** power supplies, reactors and modulators for high-voltage dc applications are covered in 12-p bulletin GEZ-2910. General Electric Company

ELECTRICAL DISTRIBUTION AND PROTECTION

130 **Capacitors,** sintered porous-anode tantalum, wet type models, are described with graphs and drawings, ratings and dimensions given in 4-p bulletin GEA-7008. General Electric Company

131 **Capacitor units** are covered in 12-p brochure GEA-6990. Power capacitors rated 50 kvar, in-line and twin-cluster pole-top units are illustrated, wiring diagrams included. General Electric Co

132 **Insulators** molded from glass-fiber reinforced polyester for 600 to 5000 v with height range from 1⅝- to 3½-in. are introduced in 4-p bulletin. Glastic Corp

133 **Resistors** are discussed in 4-p bulletin. Includes selection guide covering ratings from 13 to 500 amp. The Electric Controller & Mfg Company, Square D Div

134 **Secondary unit substations** are detailed in 44-p booklet PSG 559. Includes definitions, application data. McGraw-Edison Company, Pennsylvania Transformer Div

135 **Crane and hoist** electrification system is detailed in 4-p bulletin 76. Intermittent and continuous service ratings are shown. Feed-rail Corp

136 **Glass-tape insulation** for wire and cable is announced in 12-p bulletin WC-8319. Technical and spec data on insulation and new cable construction is included. General Electric Company

137 **Connectors** and service-entrance connections that can be installed by one man are described in 4-p bulletin. Immersion, salt-spray and current-cycling test results are included. Burndy Corp

138 **Shallow-depth switchboards** are covered in 6-p brochure 2015. Method of combining eight basic sections to meet individual applications is described. Includes incoming line, distribution and combination metering and distribution sections. Federal Pacific Electric Company

139 **Connectors** for solderless wire-splicing and terminating applications are covered in 36-p vest-pocket-sized booklet. Buchanan Electrical Products Corp

140 **Dual-element cartridge fuses** are topic of 12-p bulletin 1330. Design, construction and operation info is given. Federal Pacific Electric Company

141 **Molded-case circuit breaker** accessories and modifications are described in 12-p bulletin GEA-6757. Outline and dimensional drawings, specs aid selection. General Electric Company

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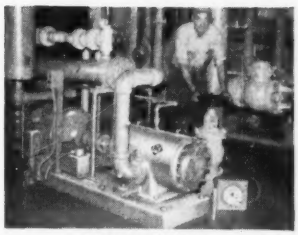
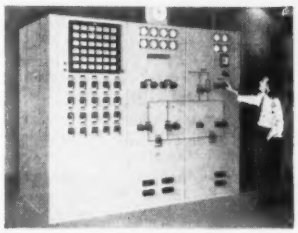
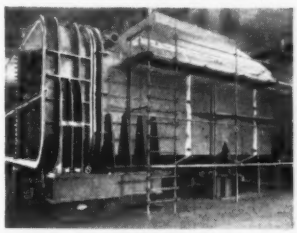


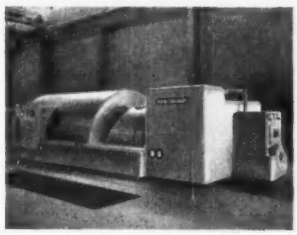
COMPRESSORS



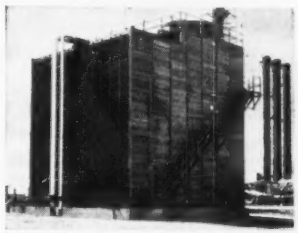
SWITCHGEAR



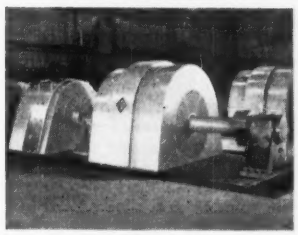
CONDENSERS



STEAM TURBINES



WATER CONDITIONING



MOTOR-GENERATOR SETS

Coordinator for a talent task force...

...he's your Allis-Chalmers man

This task force of experts bulwarks the Allis-Chalmers man. Their purpose: To offer comprehensive, single-source services to help you with preliminary power system planning, erection and operation.

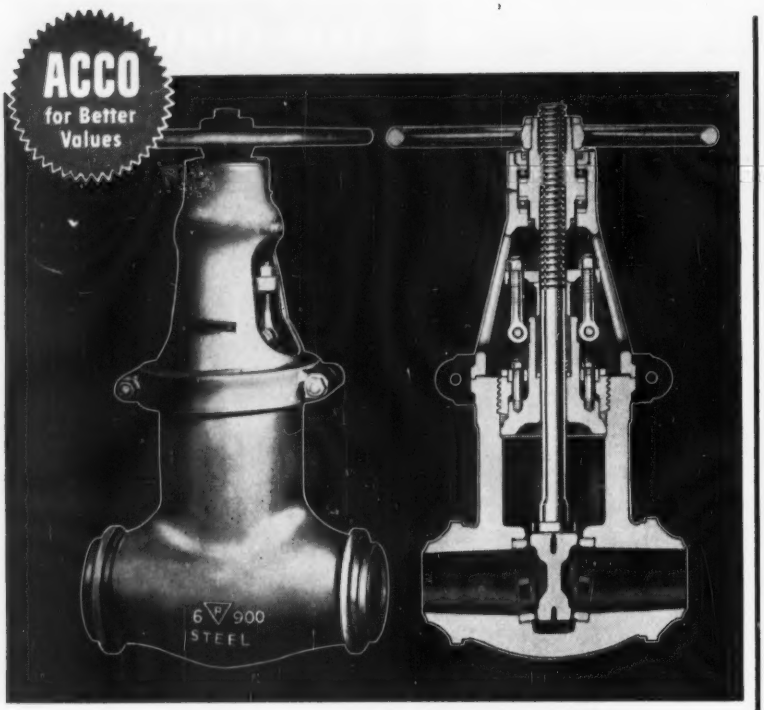
Call the A-C man in *early* . . . to put these researchers, engineers, field service men and other specialists to work on your next power project. He'll make recommendations . . . coordinate schedules of individual products to entire power systems. And you get all the benefits of Allis-Chalmers parts and service programs.

On the following pages, you'll see a few of the power products offered. Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

A-C ALLIS CHALMERS

A-1170-PR

ALLIS-CHALMERS



R-P&C Pressure Seal Valves
for high pressure, high temperature applications

The soundness and reliability of the pressure seal bonnet joint in R-P&C high pressure cast steel valves has been thoroughly proven by field experience and use. Built to give continuous dependable service in modern high pressure systems, they offer these advantages:

1. **Pressure Seal Joint designed to secure maximum mechanical efficiency. Valve bonnet may be removed or re-assembled more readily than a conventional bolted bonnet valve**
2. **Elimination of flanges reduces weight in suspended piping**
3. **Modern design with neat contours facilitates insulation**
4. **Compensating type Wedge, adjusts for tight closure and to overcome sticking or jamming when seated**
5. **Manufacturer's complete quality control. Valve Castings are produced in R-P&C foundry under the supervision of R-P&C Technical personnel. All pressure seal valve castings are subject to critical internal examination in R-P&C's own Radiographic X-ray facilities**

R-P&C Pressure Seal Valves are available in gate design thru 14″ size. Globes and Lift Checks available thru 8″ size—all in the 900-1500 and 2500 pound classes.

R-P&C Distributors offer users in the Power Industry—in addition to these Pressure Seal Valves—a complete line of R-P&C gate, globe and angle valves in all standard materials: electric furnace iron, bronze, bar stock, cast steel...plus many specialties. See your distributor or write our Reading, Pa., office.

SEND FOR FREE WALL CHART

"How to Protect Your Valves"

This 22″ x 17″ chart gives valuable installation pointers, operating tips, clues to longer service life. For free copy, write us at Reading, Pa.

R-P&C VALVES

ACCO

R-P&C Valve Division, American Chain & Cable Company, Inc.

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

Free literature

Begins on page 123A

142 **Interrupting-capacity** chart aids in selecting circuit breaker for each industrial application. Westinghouse Electric Corp

ELECTRICAL APPLICATION

143 **Power control units** utilizing magnetic amplifiers driving silicon-controlled rectifiers are described in 8-p brochure S-1075. Operational info, applications, specs included. Magnetic Amplifiers, Inc

144 **Electric power tools,** motors, flasher lights are discussed in 8-p condensed catalog. Pacific Mercury Mfg Corporation

145 **Industrial storage batteries,** stationary type, are discussed in relation to performance and longer service life in 12-p booklet 4676. Condenses operating rules applying to lead-antimony alloy batteries of low specific gravity. Electric Storage Battery Co, Exide Industrial Div

HEAT EXCHANGE, CONDENSERS

146 **Heat - exchanger - tubing** catalog outlines requirements of nuclear-quality tubing in seamless austenitic stainless steel. Tubing process is detailed. Superior Tube Company

147 **Welded-steel tubing** for heat exchangers is topic of 8-p bulletin TB-431. Firm's complete line is described. Babcock & Wilcox Company, Tubular Products Div

148 **Finned-tube heat exchangers** are subject of 4-p bulletin 11R. Models for air and gases remove excess heat from electrical generators and motors, heat or cool furnace gases. Schutte and Koerting Company

INSTRUMENTATION

149 **Dc test set,** portable, high-voltage type, is featured in spec sheet 5-1.3. Details methods for anticipating insulation failure and operational breakdown in motors and generators by nondestructive tests. Associated Research, Inc

150 **Thermistor thermometers,** telethermometers covering a range from −50 to 300 F are topic of catalog sheets. Yellow Springs Instrument Company.

151 **Indicating panel meters** and pyrometers for monitoring any electrically measurable variable are described in 12-p brochure 107. Meters are grouped by case types. Assembly Products, Inc

152 **Dc-voltage standard** and null meter can measure or supply voltages in range of 1 to 501:

ALLIS-CHALMERS

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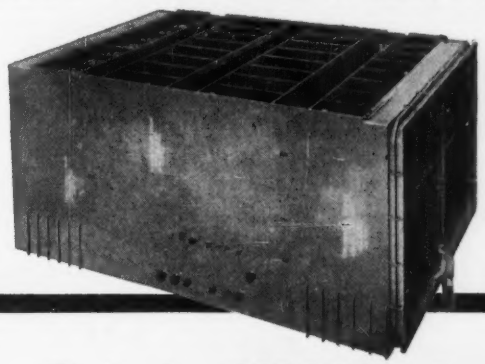
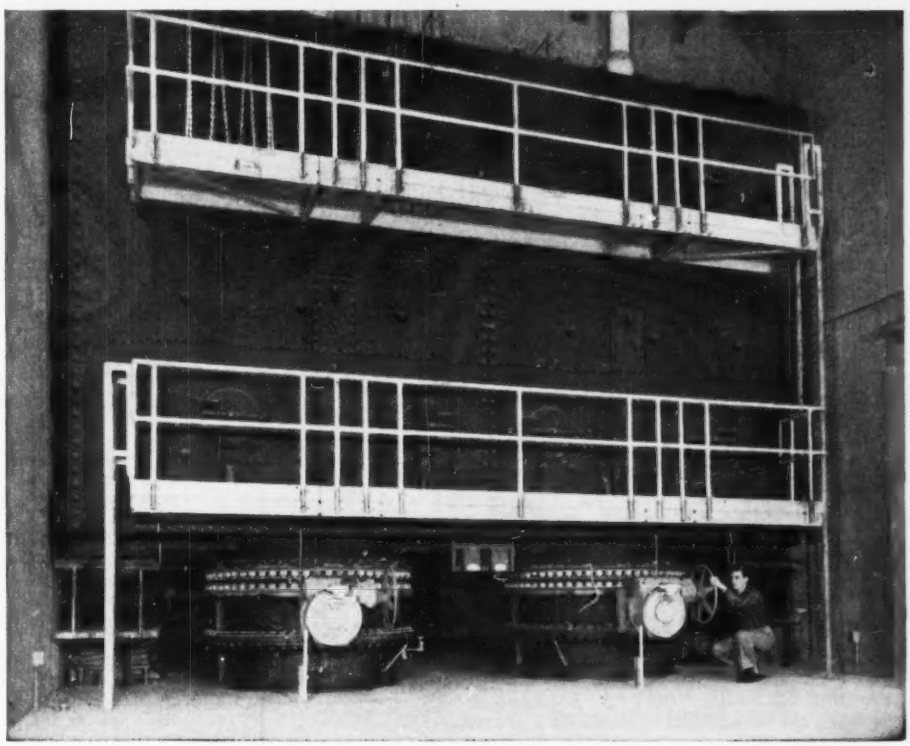


Today's BIGGEST Condenser



200,000-square-foot condenser now in operation at Fisk Station of Commonwealth Edison

Some man-sized problems were presented by this unit... not the least of which were shipping and erection. Special Allis-Chalmers well-center cars permitted shipment of the entire shell in only four sections. Special alignment techniques developed by A-C cut installation time.

Today it serves a 327-mw Allis-Chalmers steam turbine generator. Note the compact, space saving rectangular shape pioneered by Allis-Chalmers and made practical by the A-C guided-flow condenser design.

For help on your condenser problems, large or small, contact your nearby A-C office or Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

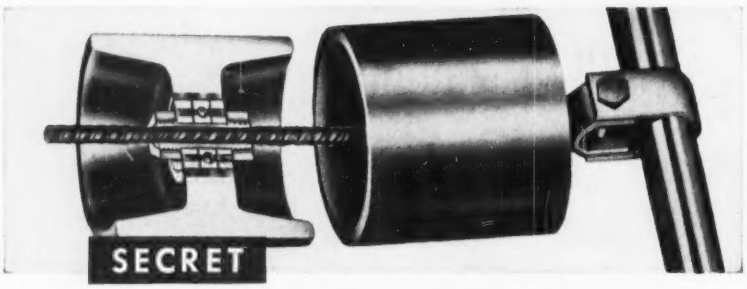
A-C ALLIS-CHALMERS

A-1046-PR

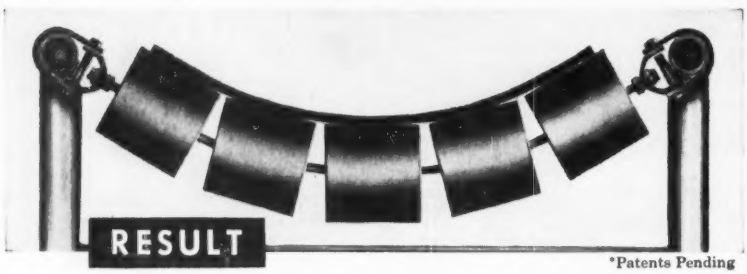
ALLIS-CHALMERS

For more facts circle 265 on Reader Service card, p 123

NEW (EXCLUSIVE WITH McNALLY PITTSBURG) CONVEYOR DESIGN ... slashes maintenance cost! ... extends belt life!



. . . of the amazingly improved efficiency of this modern belt conveyor is shown here. This new McNally Pittsburg Cradle Idler* consists of 5″ rubber rollers assembled on precision ground ball bearings, prelubricated and lifetime sealed. Being a *true catenary* suspension with rollers mounted on flexible, *non-rotating* stainless steel wire rope, this design eliminates "loping" and dangerous harmonics.



*Patents Pending

. . . is greater capacity and faster belt operation with minimum spillage. Since the belt lies in true arc with no creases or bends to cause wear, *belt life is substantially increased.* Because this McNally Pittsburg conveyor design is so simple, costs are lower, and erection time is reduced.

WRITE TODAY | for details on the new conveyor which costs less to install . . . *saves money every day it is in use.*

McNALLY • PITTSBURG

McNally Pittsburg Mfg. Corp.
Dept. PO, Pittsburg, Kansas

☐ Please send information on the new McNally Pittsburg belt conveyor.

☐ Have Sales Engineer call for further consultation.

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Free literature

Begins on page 123A

Described in bulletin 15-7. Cohu Electronics, Kin Tel Div

153 **Aluminum-case meter** with capacity of 800 cu ft per hr at ½-in. differential and 1700 cu ft per hr at 2-in. differential, 0.64 specific-gravity gas, is topic of bulletin 314. American Meter Co

154 **Accelerometers** are featured in new bulletin. Application info, mounting techniques and calibration methods are included. Endevco Corp

155 **Mass flowmeter** measures flow of fuels, industrial liquids and gases directly in lb. Meter is introduced in 8-p bulletin GEA-6925. General Electric Company

156 **Electric galvanometer,** multipurpose, is described in bulletin 14-10. Diagrams and specs included. Cohu Electronics, Kin Tel Div

157 **Field tapping kit** for tapping precision potentiometers is featured in 4-p booklet PTK-659. DeJur - Amsco Corp, Electronic Sales Div

158 **Facilities** of firm's recently established instrument div are detailed in 4-p bulletin FB-1R. Federal Pacific Electric Company

159 **Tinned - steel - case** meters with capacities from 150 to 6000 cfh are described in new product bulletin 313. American Meter Com-

160 **Instrument system** for automatic operation and control of filter plants with three- to 15-psi output pressures are discussed in brochure 1100C. Infilco Inc

161 **Differential** temperature controller, expansion type for operation at temperatures up to 2000 F, is described in new bulletin 152. Unit can be used for air-operated diaphragm valves, motors, dampers. Burling Instrument Company

162 **Automatic control systems** for hot water, steam, gas-fired and electric unit ventilators are featured in application manual. Control applications of firm's line are shown on each page. Complete cycles of operation, damper-sequence charts, specs for precise temperature control and installation are included for each unit. Barber-Colman Company

163 **Furnace- and oven-controls** bulletin B43-1C is a 40-p booklet featuring potentiometers, millivoltmeters, thermocouples, radiamatic detectors, flame-safeguard

ALLIS-CHALMERS

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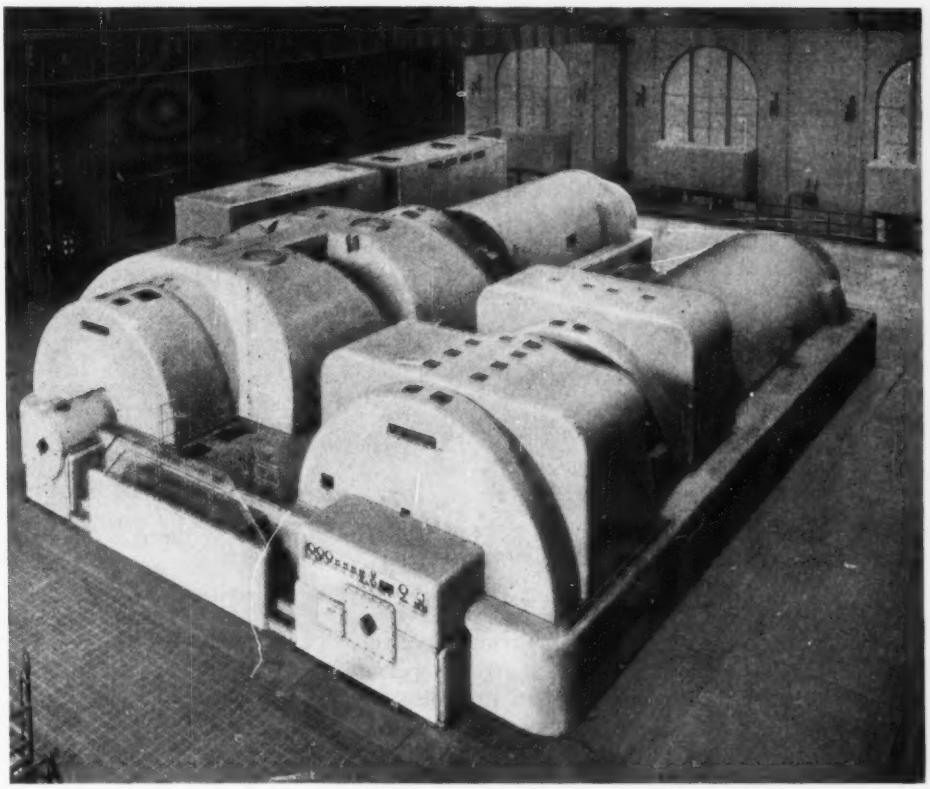


327-167-kw close-coupled, cross-compound 3600/1800-rpm unit — separate excitation m-g sets in cubicles, upper right. Steam conditions: 2000 psig, 1050 F at inlet, 1000 F reheat, 1 inch Hg absolute exhaust pressure.

Commonwealth Edison's new 327,167-kw Fisk 19 doubles station output

This steam turbine generator, the second of several such Allis-Chalmers units to go into service, is equipped with record 46-inch long exhaust blades. The unit's 200,000-sq-ft Allis-Chalmers condenser, too, is of world-record size.

Notable among today's generation achievements, Fisk 19 employs close-coupling with short crossunders, a ring-type nozzle chest, side-mounted turning gears, a double-flow intermediate pressure turbine and a fully supercharged 3600-rpm generator.

To learn more about these and other design features of Allis-Chalmers tandem and cross-compound units, see your nearby A-C office or write to Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

A-1154-PR

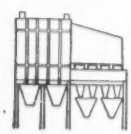
ALLIS-CHALMERS

The most efficient operating cyclone collectors made

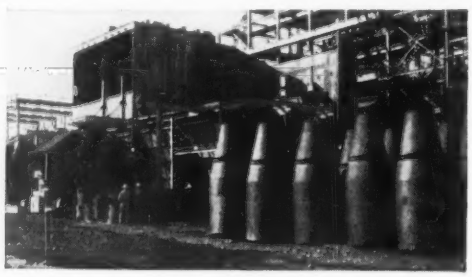
Design makes the difference: in over a thousand plants across the continent, Buell Cyclones have *proved* themselves more efficient than any other cyclones made. Buell's exclusive Shave-off port (A), traps the extra percentage of dust that ordinary cyclones lose. And large-diameter (B), custom-engineered design eliminates bridging, clogging, or plugging during operation, keeps efficiency high without interruption. Regardless of your present or planned plant layout, Buell equipment can be designed to solve your dust collection problems efficiently and economically. There's valuable information in a concise booklet, "The Exclusive Buell Cyclone". Write Dept. 50-L, Buell Engineering Company, Inc., 123 William Street, New York 38, N. Y.

BUELL CYCLONES

"SF" ELECTRIC PRECIPITATORS



PRECIPITATOR-CYCLONE COMBINATIONS



Buell Cyclones before installation at a major plant.

buell®

Experts at delivering Extra Efficiency in

DUST COLLECTION SYSTEMS

Free literature

Begins on page 123A

systems and industrial controls. Price list, illustrations included. Minneapolis - Honeywell Regulator Company

164 **Hook-on volt ammeter** for testing ac voltages is described in 4-p bulletin GEA-6292C. Specs included. General Electric Co

165 **Instrument budgets** are discussed in case history. Shows how you can save money by using centralized source of electronic-test-instrument info. Technical Information Corp

166 **Installation** - through - startup service for automation and instrumentation systems is described in 16-p brochure 107. Panellit Service Corp

167 **Recording instruments** are topic of 12-p bulletin GEA-6933 which provides buying info on firm's complete line. Dimensions, chart speeds, applications and specs included. General Electric Co

168 **Recording and testing** instruments are described in new condensed catalog G-10. Details firm's complete line. Minneapolis-Honeywell Regulator Co

169 **High - intensity stroboscope** for nondestructive testing covering speeds from 60 to 15,000 rpm is introduced in bulletin 780. Herman H Sticht Co, Inc

170 **Electric indicators** and controllers, dc millivoltmeter and bridge-type models, are featured in 10-p bulletin GEA-2898. Typical measurement applications, principles of operation are included. General Electric Co

171 **Thermostats,** adjustable heat regulators and magnetic relays are described with specs in bulletin T-5. Precision Thermometer Instrument Company

172 **Electric process-control** system is described in data sheets. Complete line of transmitters, transducers, receivers, controllers and final control elements that make up system is outlined. Minneapolis-Honeywell Regulator Co

173 **Load-control systems** are discussed in 4-p bulletin GET-2916. Tie line and frequency, reactive power and power-limiting control are topics included. General Electric Company

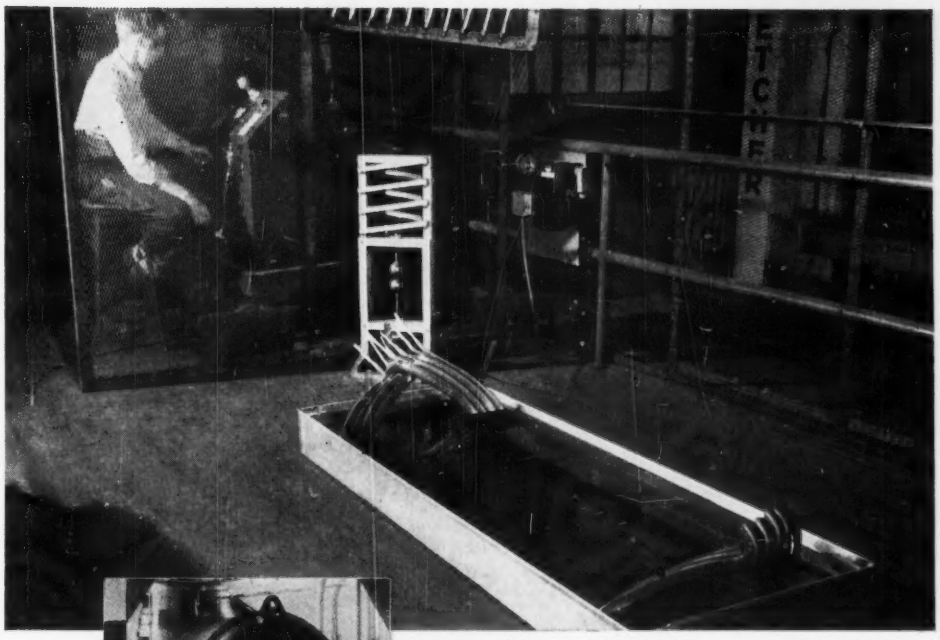
WELDING

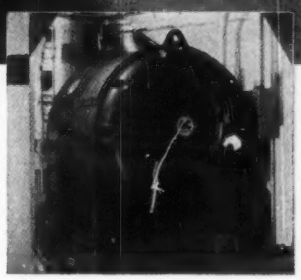
174 **Welding-wire** pocket guide has 84-pp, includes info on firm's complete line of gas-shielded metal-arc welding wire, steel wire, chemical composition, mechanical properties and operating procedures of the welding process. Air Reduction Sales Co

continued

In pace with POWER... ALLIS-CHALMERS

ALLIS-CHALMERS





Moisture-resistant *Silco-Flex* coils are high-potential-tested under water, with test voltage applied for one minute between conductor and water bath.

Super-Seal
coil foils water

"Hi-pot" tests under water prove moisture resistance

Remarkable insulation systems combined with advanced mechanical features provide a completely new concept in motor protection — the *Super-Seal* motor. This motor gives you complete protection from moisture, fly ash, and other contaminants, even with so-called drip-proof motor enclosures.

New motor is protected with *Silco-Flex* stator coil insulating system: A homogeneous, void-free dielectric barrier of vulcanized silicone rubber so moisture-proof it can be hi-potted under water, cleaned by hosing down. Resists most corrosive or chemical atmospheres.

Integrated field coils in synchronous machines are completely sealed against contaminants, bonded and locked against mechanical forces.

For additional information, call your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

Super-Seal and *Silco-Flex* are Allis-Chalmers trademarks.

A-C ALLIS-CHALMERS

A-5992-PB

ALLIS-CHALMERS

ROTO Hand-hole Seat Scraper

Roto Hand-hole Seat Scraper for B & W Boiler.

Eliminates tedious labor

Assures clean, tight fit

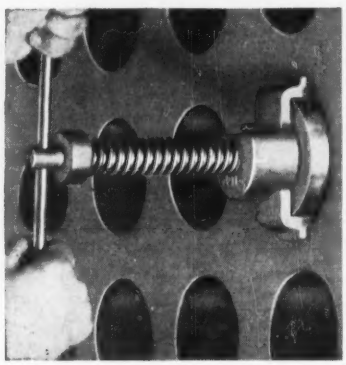
Roto Hand-hole Seat Scraper makes short work of cleaning dirty hand-hole seats. This simple, hand-operated tool has adjustable, spring-mounted retractable knives. A few turns to the right remove foreign matter without cutting the metal. A half turn to the left releases the tool, and the job is done. Customers say that the Roto Seat Scraper does the job up to 12 times faster than by any other method. Try one and you'll wonder how you ever got along without it. *Send for details.*

Now available

for most hand-hole shapes and sizes

ROUND SQUARE DIAMOND PEAR OVAL

Standard Roto Seat Scrapers are available for the following equipment. Special types made to order.



Illustrating ease of operation of Roto Hand-hole Seat Scraper.

Type of Boiler	Opening	Tube Size
Babcock & Wilcox # 4	Round	2"
" " " #41	Oval	2"
" " " #70	Round	3"
" " " #48	Oval	3½"
" " " #40	Oval	3¼"
" " " #24	Oval	4"
" " "	Oblong	4"
Bros	Round	3¼"
Casey Hedges	Oval	3½"
" "	Oval	4"
Combustion Eng'rg	Round	3"
" "	Oval	3"
Edgemoor	Oval	4"
Erie City	Ellip	2½"
" "	Oblong	3¼"
" "	Ellip	3¼"
" "	Pear	4"
Foster Wheeler	Oblong	2½"
" "	Oblong	3"
" "	Ellip	4"
Geary	Oblong	4"

Type of Boiler	Opening	Tube Size
Heine	Round	3½"
"	Oval	3½"
International Boiler 2	Oblong	3"
Keeler	Round	3½"
"	Round	4"
"	Diamond	3½"
"	Diamond	4"
Lasker	Oblong	
Murray	Oval	3½"
"	Oblong	4"
Oil City	Oval	3½"
" "	Oblong	4"
Riley Stoker	Ellip	3¼"
Springfield	Ellip	3¼"
Union Iron Works	Pear	4"
Henry Vogt	Ellip	3¼"
" "	Oval	4"
Walsh & Weidner	Oval	4"
Wickes	Ellip	2½"
"	Ellip	3¼"
"	Pear	4"
"	Round	4"

ELLIOTT COMPANY – ROTO PLANT

Tube Cleaner Specialists Since 1910

153 Sussex Avenue, Newark, N. J.

Free literature

Begins on page 123A

175 **"How to weld" handbook** includes 24-pp plus circular slide rule to determine correct heat amounts as related to amperes, volts and speed of welding arc. United States Steel Corporation

176 **Procedures** for making permanent electrical connections to any copper conductor or steel structure are described on wall chart. Burndy Corporation

LUBRICATION

177 **Bottle oilers,** oil cups and constant-level oil controls are detailed in 4-p circular 580. Lunkenheimer Co

178 **Lubricant** for use at high temperatures and discussion of problems involved in assembly and run-in operations are featured in new literature. Acheson Colloids Company

NUCLEAR ENERGY

179 **Nuclear** and diesel power operation are described in 28-p publication. Process involved in making reactors, components, development and experience with a diesel engine are featured. Alco Products, Inc

180 **Department facilities** for irradiation services are described in new bulletin GEA-6934. General Electric Company

181 **Control rods** for all reactor applications are detailed in 4-p illustrated bulletin GEA-6609. Twin-screw, oil-hydraulic or pneumatic; locking-piston, water-hydraulic; single-screw; rotating nut and gear and rack drives are types included. General Electric Company

MECHANICAL POWER TRANSMISSION

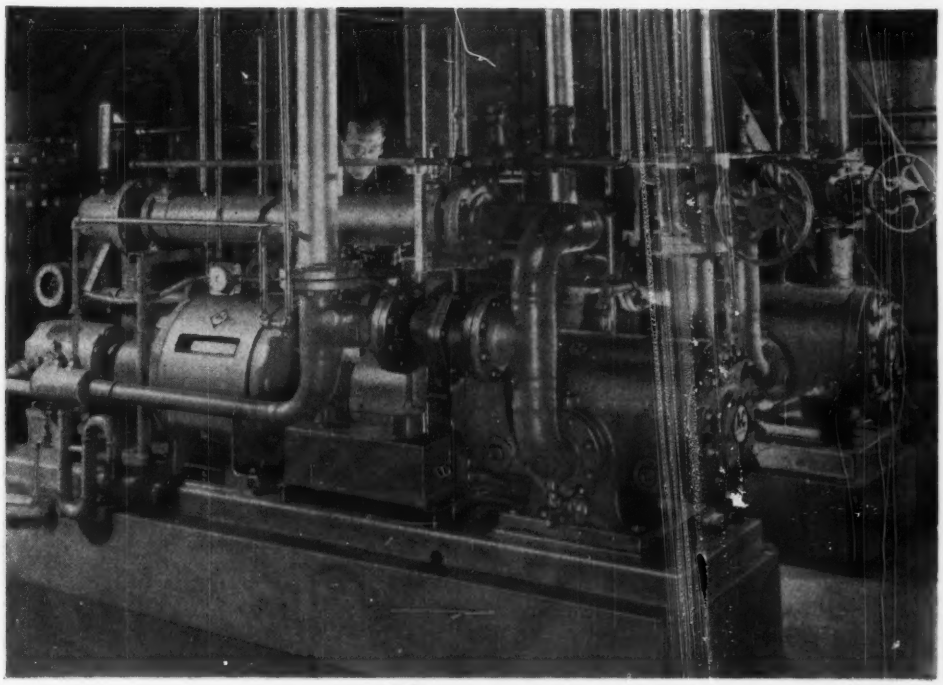
182 **Helical-gear speed reducers** in double, triple and quadruple reductions are featured in 20-p booklet 2751. Hp and torque ratings, dimensions, mounting arrangements are given along with resumé of construction features. Link-Belt Company

183 **Variable-speed motor drives** are detailed in 88-p catalog. Firm's complete line is detailed with speed and hp tables, capacity ratings, dimensions, accessories, modifications and price lists. Included also is a special section on horizontal and vertical models, 25 through 40 hp. Reliance Electric and Engineering Co, Reeves Pulley Co Div

184 **High-hp speed reducers** for cooling towers are featured in bulletin 135-S. Rating tables, dimensions, installation instructions are included. The Cleveland Worm and Gear Company

ALLIS-CHALMERS

In pace with POWER... ALLIS-CHALMERS



Ro-Flo vacuum pumps reduce pressure in condenser in power plant.

Smooth and Tough

Eliminate high maintenance with Ro-Flo compressors and vacuum pumps

Ro-Flo units can take it! They're being used successfully on hundreds of jobs, including: shop air, air tools, condenser vacuum pumping, air hoists, cleaning, sandblasting, riveting, sewage ejectors, peak shaving of gas and air drilling.

The inherent wear and tear from the vibration and shock of reciprocating machines is eliminated in the smooth *Ro-Flo* rotary action. The fall-off in efficiency, inevitable with other units, never takes place with a *Ro-Flo* compressor. And the tough sliding vanes operate for thousands of hours before new ones are slid into place in a job that takes only 30 minutes.

For smoothness, for toughness, for easy maintenance and simplest installation, choose *Ro-Flo* compressors.

Contact your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

Ro-Flo is an Allis-Chalmers trademark.

A-C ALLIS CHALMERS

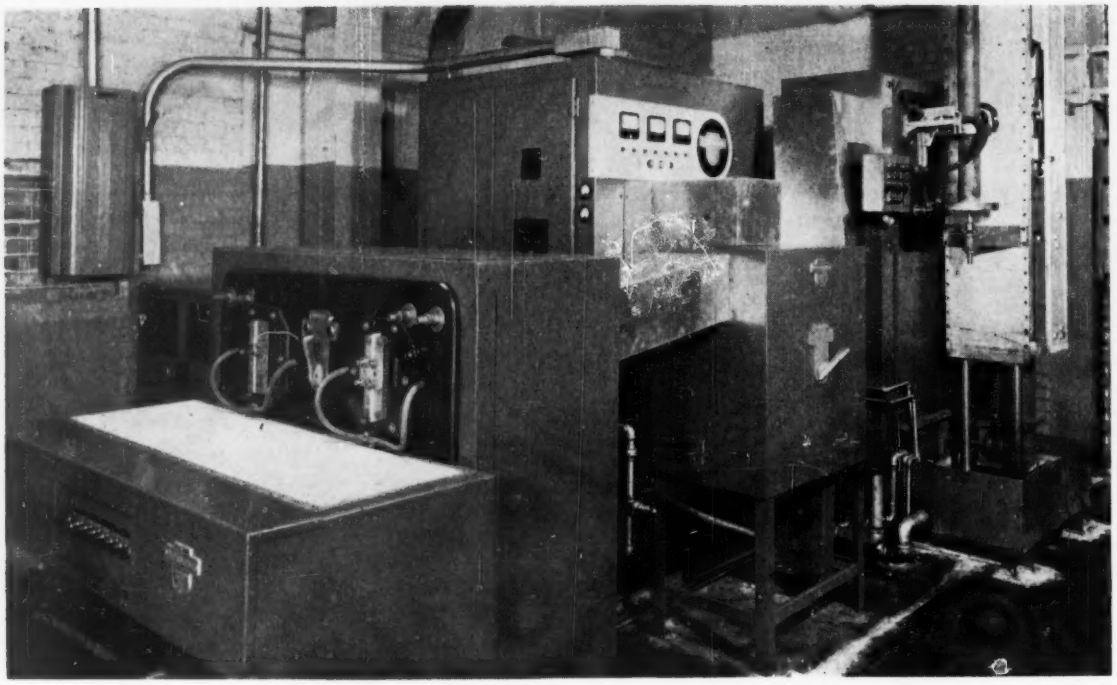
A-5960-PR

ALLIS-CHALMERS

Equipment design of the month

By STEVE ELONKA
Associate Editor

On this page each month you'll see the wraps taken off a significant new product, material or process for the first time in the power field



Heat-treating package tackles preventive maintenance

Here's a complete induction heat-treating shop for your maintenance work. A 2-position quench type work station, radio-frequency power-transfer switchgear, vertical progressive scanning machine and induction generator are packaged to handle all hardening jobs from cams and gears to components 6-ft long and 10 in. in diameter. Package takes up only 10x20 ft of floor space.

Ther-Monic, introduced by Induction Heating Corp, Brooklyn N. Y., features a series of eight checklights to pinpoint abnormal conditions immediately, minimizing your trouble-shooting headaches. External gages conveniently indicate water pressure and temperature. Internal protective switches automatically guard against possible damage by low water flow and pressure and excessive air and water temperature.

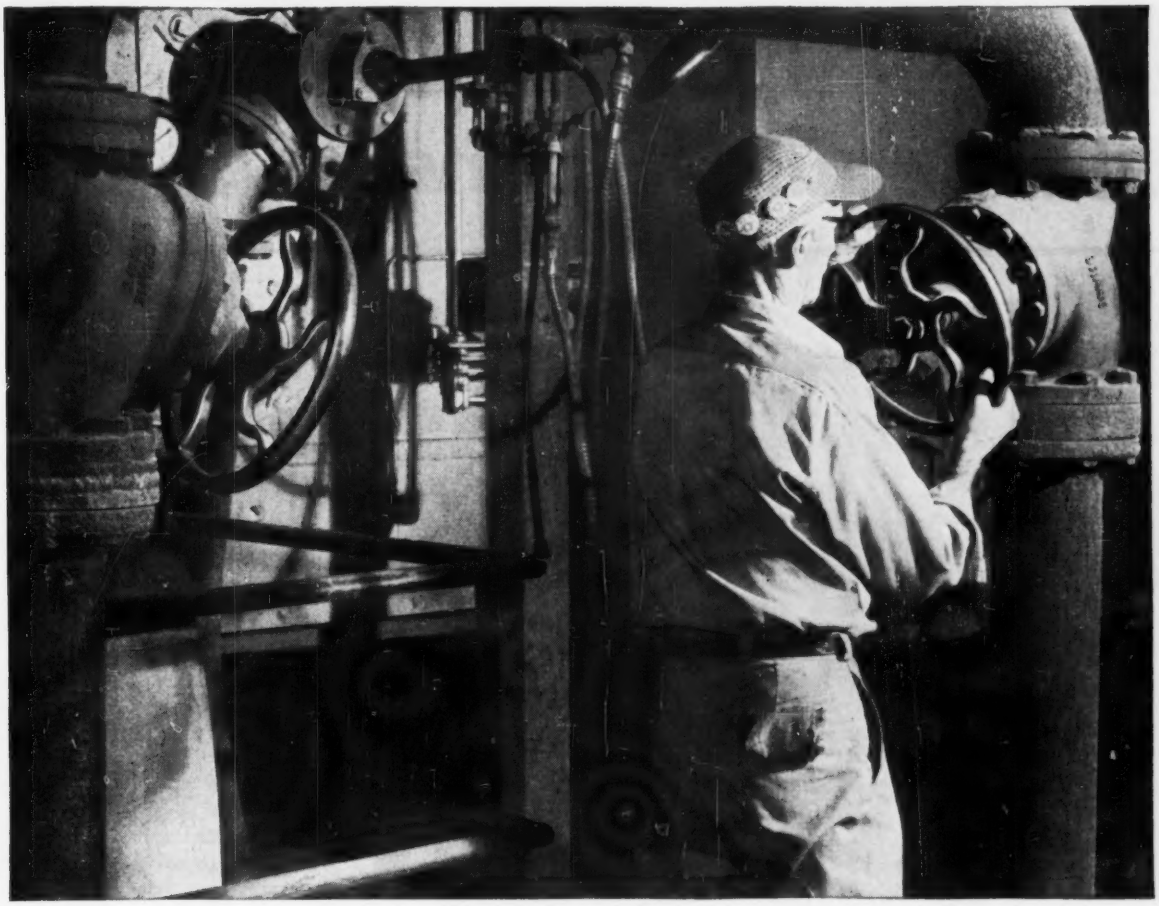
Quench type work station consists of variable-ratio rf (radio-frequency) iron-core output transformer, manually operated rf transfer switch for applying power to either station, two multicircuit process timers for controlling heat quench and fixture cycles, automatic-quench solenoid-operated valves, flow regulators.

Pushbuttons control all automatic cycles and momentary operation of various circuits needed for setup. In back of the work station is a special rf selector switch for transferring high-frequency selector power to either the general-purpose heating station or the vertical scanner station in the rear.

A vertical scanner progressively hardens steel shafts from 4-in. diameter to 6-ft long, and with diameters up to 10 in. Carriage is motor-driven through cam-operated switches to top and bottom limits; reverse; fast, medium and slow transverse; and heat-on, heat-off.

You can use *Ther-Monic* under any ambient temperature conditions—a built-in air-conditioning system of water-to-air heat exchanger and blower circulates cool air through power supply and rf compartments.

For additional information, circle No. 89 on Reader Service card, page 123



Crane diaphragm valves on gas lines to boilers...8 years with no maintenance

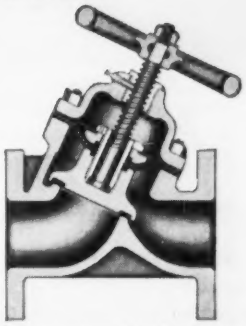
Before Union Electric Co.'s Venice Station, St. Louis, changed to Crane packless diaphragm valves, the plug valves used on natural gas fuel lines to boilers were causing costly maintenance. Records showed excessive repacking and accelerated seat wear.

Since changing to Crane valves in 1951, there has been no leakage, no seat wear, no trouble of any kind. Tight seating is assured by the resilient, neoprene disc-insert that actually absorbs hard foreign particles. The disc and diaphragm are separate members. The diaphragm functions only to seal the bonnet and is not subject to the crushing or severe flexing that can cause early rupture in ordinary diaphragm valves. The disc insures tight closure even if the diaphragm should fail. After eight years' continuous, maintenance-free service, the Crane valves still seat tight—show no sign of wear.

The same Crane features that perform so well on gas service save Union Electric many maintenance dollars on raw river water lines used for ash sluicing and on compressed air and other water lines. They can do the same for you.

Write for free booklet

Get the complete story on Crane diaphragm valves. Ask your Crane Representative for Bulletin AD-1942, or write to the address below.



Note separate disc-diaphragm construction. Diaphragm serves only as bonnet seal while disc does the seating—holds line fluid even if diaphragm should fail. Wide choice of body, trim and lining materials. Screwed or flanged ends.

CRANE® VALVES & FITTINGS

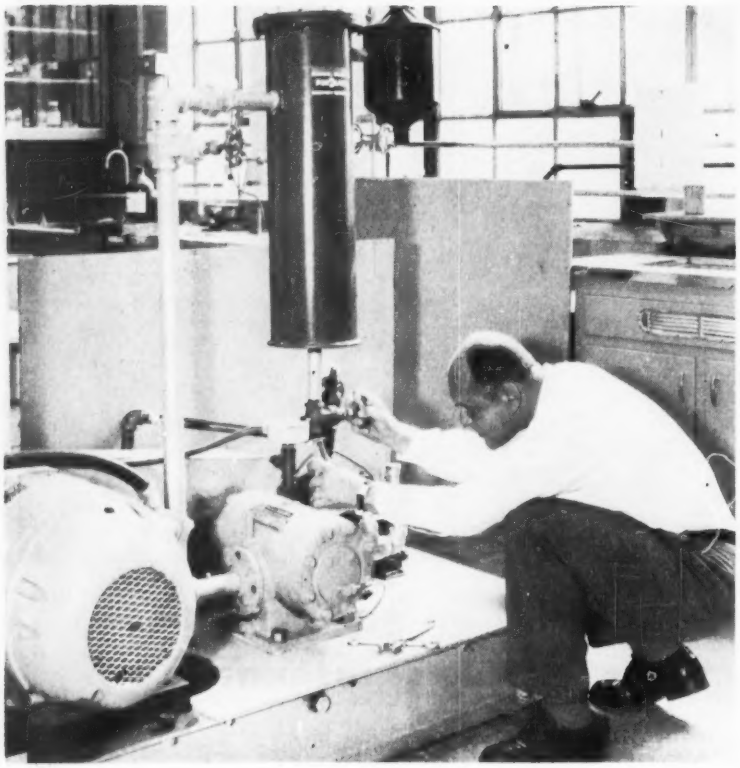
PIPE • PLUMBING • HEATING • AIR CONDITIONING

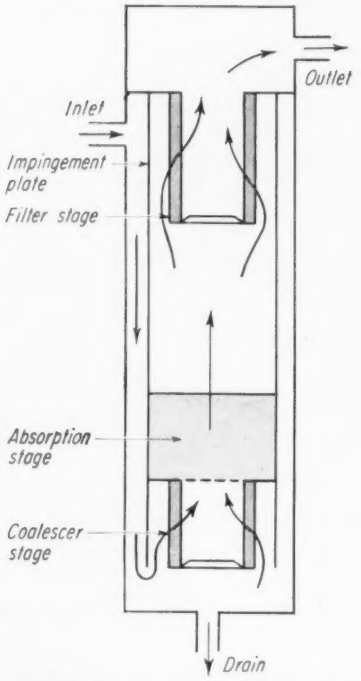
Since 1855—Crane Co., General Offices: Chicago 5, Illinois—Branches and Wholesalers Serving All Areas

In Canada: Crane, Limited, 1170 Beaver Hall Square, Montreal, Que.

For more data on these developments, circle key numbers on Reader Service card, p 123

Plant equipment news... Your





OIL MIST is removed by impingement, coalescence, absorption and filtration stages

←
DRAINING a four-stage installation which filters oil - mist - laden compressed air

Filter removes oil mist from compressed air

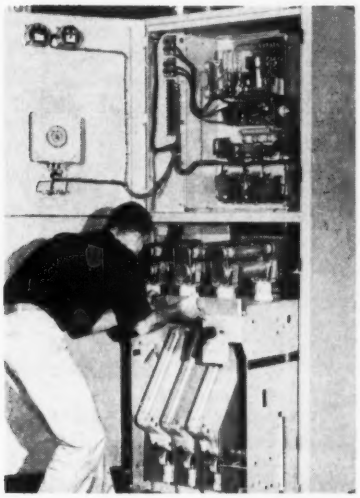
1 • New concept in compressed air filtration removes up to 95% submicronic oil mist. System involves four stages—impingement, coalescence, absorption and filtration. Depending on specific application, any or all of the four stages may be used.

Impingement stage removes large droplets of oil by physically impinging them on the baffle plate. Filtration stage employs a standard air filter element which polishes the final air. The coalescence stage causes the extremely small particles of oil to become larger particles.

In the absorption stage, a bed of clay is fluidized by air passing through it. This gives it the appearance of "boiling" and exposes large particle areas to the oil mist permitting maximum absorption. Clay bed occupies about 1/3 of the total volume of the absorption cylinder when no air is passing through it. At a velocity of 4 ft per sec, the buoyant forces of the air cause the clay to become fluid. Entire bed lifts up and occupies total volume of the absorbing cylinder. Clay bed can be of any absorbent material such as active alumina. A filter rated at about 45 cfm will operate 300 to 400 hr before a new charge of clay is required. Pressure drop is about 5 psi when new, tending to increase slightly with use.

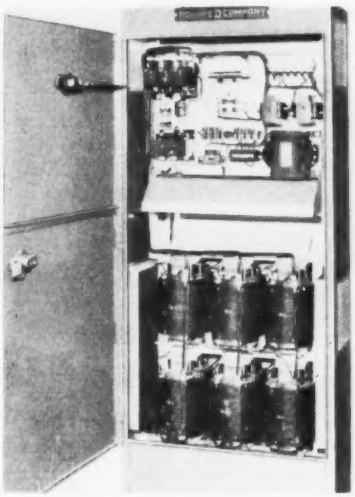
At velocities over 8 ft per sec, entire clay bed rises to the top of the cylinder and becomes compressed against the polishing filter. The fluidization ceases and desired intimate contact between clay particles and the oil mist no longer exists. Therefore velocities in the absorption cylinder must be carefully calculated and controlled. Special designs are available for widely varying air flow ratings. Before the air reaches the fluidized absorption bed, it must be free of water. Excessive moisture will destroy the ability of the bed to absorb oil mist.—Purolator Products, Inc

information center for new products and materials



Ac motor starter has unique draw-out

2 • Redesigned medium voltage ac motor starter features new draw-out contactor and fuse-shelf assembly. Unit is designed to provide short-circuit protection and coordinated control for squirrel-cage, synchronous, and wound-rotor motors up to 3000 hp rated from 2300 to 4600 v. Draw-out, stab-in contactor and fuse assembly should shorten installation time. "Door forgetter" keeps h-v compartment closed when starter is energized.—General Electric Co



Adjustable voltage drive claims quiet operation

3 • Magnetic amplifiers and semiconductors are used for control and rectification of input power in this unit. Minimum of maintenance is required because components operate well within their ratings, states maker. Static power drives are available as standard packages in sizes ranging from ½- to 200-hp. They feature an 8/1 speed range with 5% regulation. Unit is particularly applicable where warm-up time or vibration cannot be permitted.—Square D Company

Dry type transformers for 400-cycle systems

4 • Single and three phase, 400-cycle dry type transformers rated 500 kva, 600 v and below operate for air frame assembly line test facilities, ground power supplies, portable test equipment and any type of 400-cycle distribution system. Compound-filled construction of models allows mounting in any position. Since they contain no flammable liquids or vapors, installation of units indoors or outdoors is possible. Units are built in accordance with ASA, NEMA and AIEE standards for transformers.—Westinghouse Electric Corp

Differential relay has all static design

5 • High-speed generator relay provides protection from damage due to three-phase, phase-to-phase, two-phase-to-ground and phase-to-ground faults, says manufacturer. All static unit with protective circuit functions needs no auxiliary transformers or other external components. When connected, burden of 0.25 va results on current transformer operating at 5 amp, 60 cycles. Minimum operating current of relay is 0.14 amp.—Westinghouse Electric Corp

Plug-in bus duct exhibits safety features

6 • New system for distributing electricity can withstand unusual electrical and mechanical stresses, incorporates lowest possible voltage drop practicable, states maker. *XL Bustribution Plug-in Duct* will be available in January in amp ratings of 225 through 1000, voltage ratings through 600 ac single-phase, 3-phase and 4-wire.

New duct will be available in 10-ft lengths for easy handling and installation. When installing a bus plug, plug-in cover must be closed until switch plug is in a safe position. It is almost impossible for an electrician to touch a live bus bar.—I-T-E Circuit Breaker Company.

For more data on these developments, circle key numbers on Reader Service card, p 123

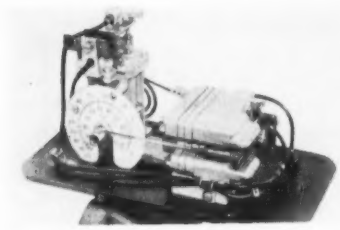
More **equipment news**

For more data on these developments, circle key numbers on Reader Service card, p 123

Ultrasonic corrosion detector gives inch-reading

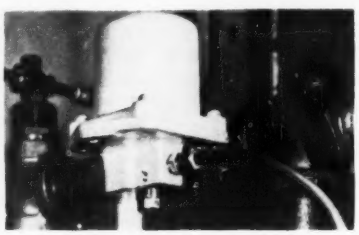
7 • Portable ultrasonic thickness gage uses pulse-echo method of detecting changes in metal thickness to spot flaws and small discontinuities in metals and other materials, says manufacturer. No larger than a portable radio, versatile gage uses transistors and low-voltage batteries. It's said to be explosion resistant.

Measurements may be read directly on a calibrated meter—no bother of interpreting them through oscilloscope and charts. Operator adjusts the "material" dial for metal being inspected and instrument reads directly in inches. Accuracy is within 1% of full scale. Over 3-ft maximum thickness can be gaged in aluminum and steel; minimum thickness is .060-in. aluminum and .070-in. in steel. Unit weighs only 10 lb.—Sperry Products, Inc



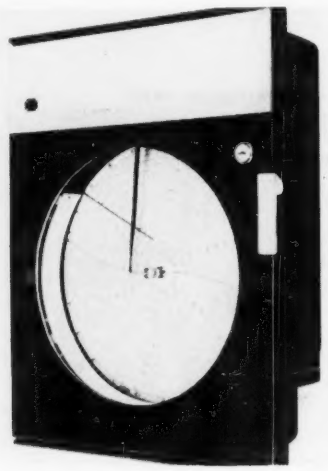
Function generator boasts accurate readout

8 • Compact unit provides pneumatic output that varies as a prescribed function of a pneumatic input. Principle use is in linearizing the signal from a differential-pressure type flow transmitter. You can use it to measure and control feedwater or steam flow in power production, maker suggests. Air consumed is 0.2 scfm, input and output—3 to 15 psi pneumatic. — Taylor Instrument Co



Pressure detector operates to 3000 psi

9 • Pressure detector in combination with monitor converts pressures from in. Hg directly to an electrical resistance. Pressure-sensing element linearly varies terminal resistance of low - temperature - coefficient alloy winding, permits operation over 32- to 150-F range. Size of Model 328 is 2 5/16 x 2⅛-in. with ¼-in. standard pipe thread inlet.—McGraw-Edison Company, Instrument Div



Temp-pressure recorder features better readability

10 • Redesigned 12-in. recorder has recessed bottom permitting one type connection for both wall and panel mounting. Extra-large "in" door improves recording - chart visibility. Filled-system thermometer elements measure temperature from −300 to 1200 F; pressures from 30-in. Hg of vacuum to 25,000 psi are recorded.

White window skirt on door gathers light for improved readability of chart records, says manufacturer.—American Machine & Metals Inc, United States Gauge Div

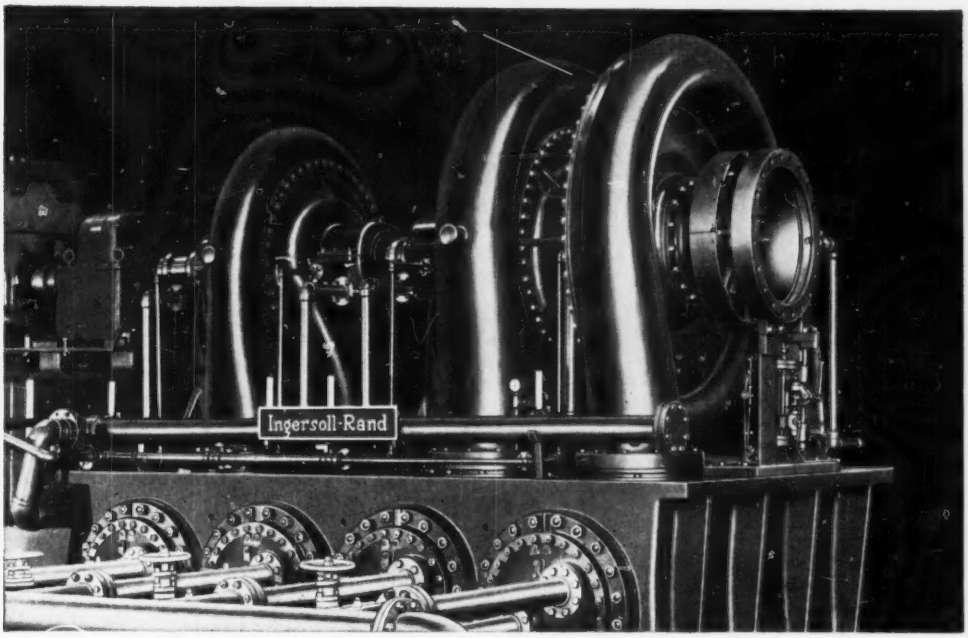
High-pressure gage handles applications to 100,000 psi

11 • This 6-in.-diameter gage is available in twelve ranges from 1000 to 100,000 psig. Multiturn helical bourdon tube of special drawn-and-formed 316 stainless steel gives longer life, greater accuracy, states manufacturer. Divisions of dial are spread over 300 degrees in all ranges for maximum readability.

Safety features include high-tensile safety plate between element and viewer and a laminated safety dial glass. Movement is of stainless steel throughout and special linkages are said to reduce shock and vibration.—Astra Corporation

For more data on these developments, circle key numbers on Reader Service card, p 123

ANOTHER **NEW DEVELOPMENT** FROM INGERSOLL-RAND



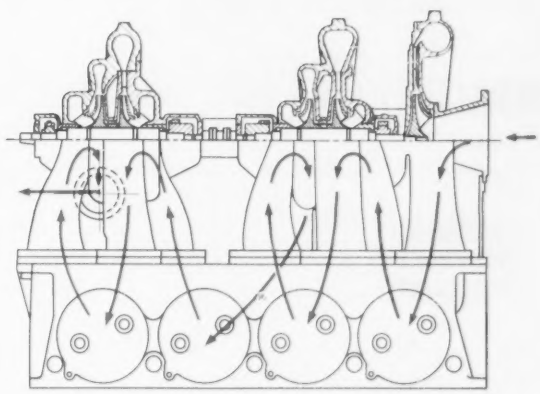
New 100 psi Centrifugal Air Compressor delivers up to 35,000* cfm

Five-Stage Intercooled Unit provides new efficiency and economy, with big savings in space and weight

THE Ingersoll-Rand CVM Centrifugal Compressor represents a new concept in the efficiency and economy of large-capacity air compression in the 100-125 psi range. With five compression stages and intercooling between each stage, it approaches the ideal *isothermal design*, delivering more air per horsepower than any other type of multi-stage centrifugal compressor.

The five impellers are mounted on two shafts, with two impeller pairs back-to-back to minimize axial thrust. The short shaft construction permits operation below first critical speed, minimizing vibration and extending the life of bearings and seals. The water-cooled intercoolers are integral with the machine base, have all water connections on the same side, and can be cleaned while the compressor is in operation.

The CVM Centrifugal Compressor is available in ratings to 35,000 cfm for discharge pressures to approximately 125 psi. For further details, see your I-R representative or write to Ingersoll-Rand.



Side elevation drawing of a CVM Centrifugal Air Compressor with top half of casing sections cut away to show impeller arrangement. Arrows indicate air flow through impellers and intercoolers.

Ingersoll-Rand

12-988 11 Broadway, New York 4, N. Y.

**Higher capacities available with other designs.*

COMPRESSORS • GAS & DIESEL ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

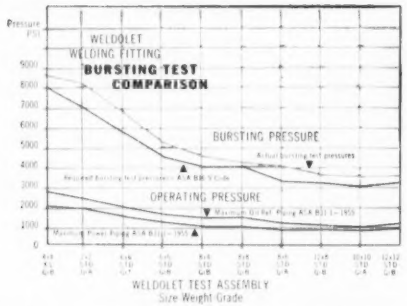
new redesigned BONNEY WELDOLETS

for reinforced branch connections on carbon steel and alloy pipe

Welding fittings manufactured and tested in accordance with ASA B16.9 and ASA B31.1

clean-cut bevel with exactly 1/16" land
bore machined with a watchmaker's precision and finish
reduced angle of bevel ... weld volume cut almost 50%
weld line clearly defined ... no more errors about "how much to weld"
skirt taper redesigned for improved stress distribution

RESULTS? OVER 4½ TIMES MAXIMUM OPERATING PRESSURE



BONNEY

WELDOLETS®
THREDOLETS®
SOCKOLETS®
ELBOLETS®
BRAZOLETS®
SWEEPOLETS®

CARBON STEEL
STAINLESS
ALLOY
for all services

For high strength and low-total installed cost compare with . . . other reinforced branch construction . . . unreinforced branch construction . . . and welding tee construction. Then specify and use Weldolet fittings for all full size and reducing branch connections.

BONNEY FORGE AND TOOL WORKS

ALLENTOWN, PENNSYLVANIA

Equipment news

Begins on page 134

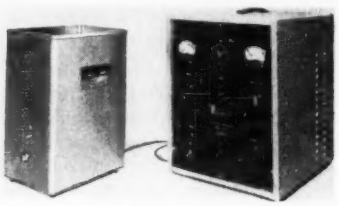
Aluminized asbestos cloth

23 • Asbestos cloth with 0.0004-in. aluminum coating is laminated with a heat-resistant adhesive. Flexible combination is more than 90% effective in reflecting radiant heat, states maker. In tape form it is highly adaptable as an outer wrap for pipe lines.—Johns-Manville Co

Just circle key numbers on the Reader Service card, page 123, to get complete product story

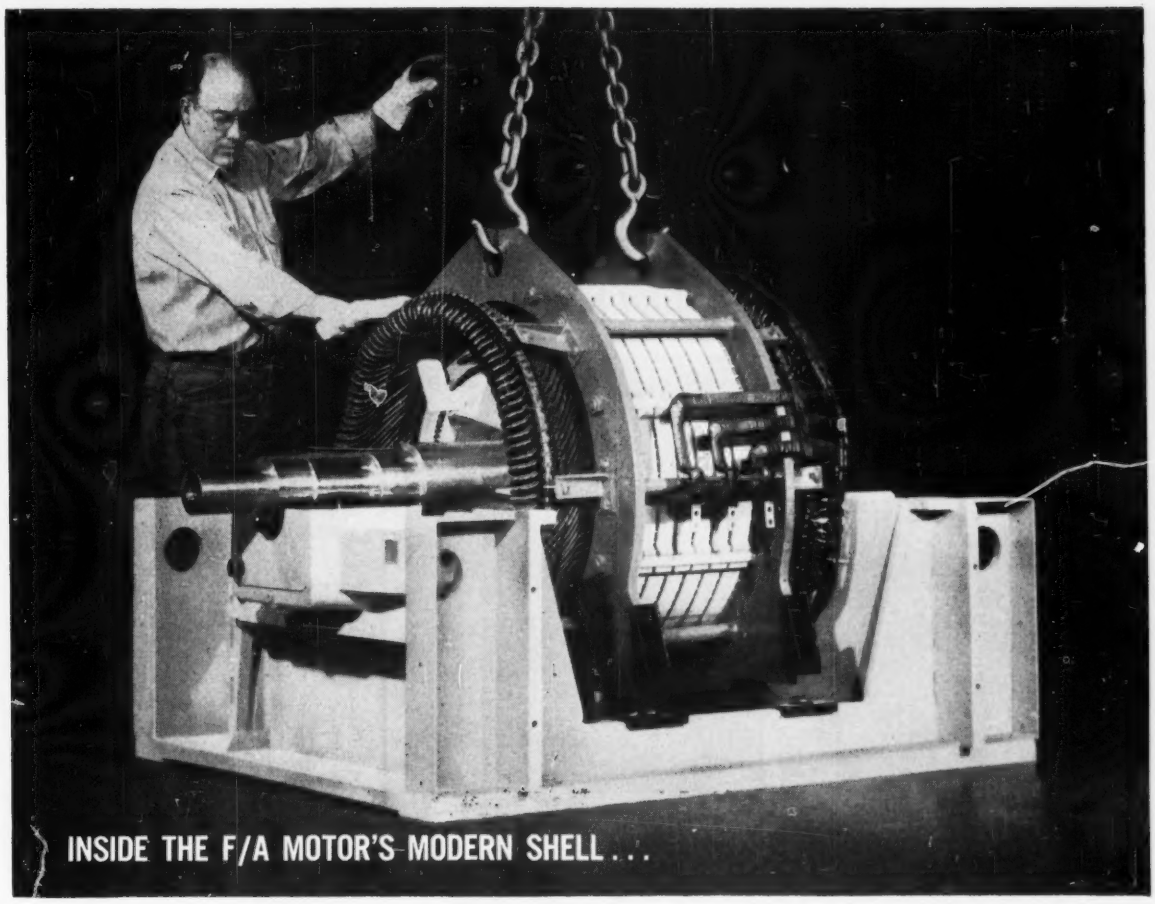
Dielectric test set

49 • Combination high - potential tester and fault tracer tests cables at voltages to 60,000-v dc and automatically supplies tracer current to a faulted cable. The dc tracing-current section provides pulsed power of either 16,000-v dc and up to 250 ma at 30,000 v and below.—Sorensen & Company



Ultrasonic cleaning unit

29 • For use where high-energy-density ultrasonic cleaning is required, unit features a 5-gal heavy-gage polished stainless-steel tank 12-in. long, 12-in. deep and 9-in. wide. A 115-v ac single-phase 60-cycle generator, designed for continuous oper-



long life, lowest maintenance, backed by 7000 success stories

WEATHER-TESTED FOR OVER TWO YEARS...WITH NO MAINTENANCE!

This conventional indoor, 600-hp motor with Thermalastic insulation has been running outdoors for more than two years. Built before the F/A Motor was introduced, it has been subjected to these rigorous conditions:

- Twenty-four hours a day, five days a week, with weekend shutdowns to produce stopping and starting surges
- Summer and winter, all weather and temperature extremes
- Two-week shutdown during which it was sprayed almost continuously with fire hoses

It is still running smoothly and shows no signs of insulation breakdown or other deterioration.

In 7000 large-motor installations and over 15 million horsepower of Westinghouse large rotating apparatus, not a single breakdown occurred from Thermalastic® insulation failure.

One reason for this amazing service record lies in the unique molecular structure of Thermalastic insulation. Large, overlapping mica splittings are locked in a void-free, memory-type elastic bond, forming a perfect dielectric barrier which is maintained under *all* operating conditions.

Because of Thermalastic, your F/A Motor serves you longer and better. This insulation system withstands prolonged voltages, abrasion, corona arcing and frequent-starting surges. F/A Motor applications are virtually unlimited because Thermalastic is chemically stable, will not react, dissolve, crystallize or evaporate in contact with acids, alkalis, oils, lamp black, dirt, moisture or temperature extremes.

Consider what these proved performance extras can mean in down time and maintenance savings alone. For more specific test data, call your Westinghouse representative, or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. J-15013

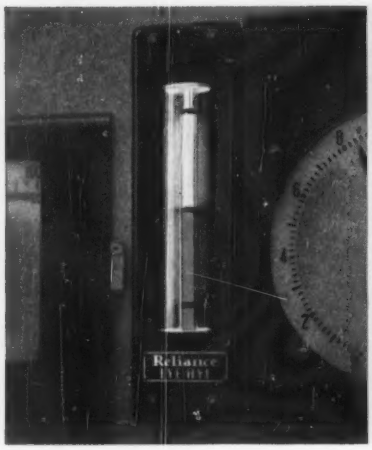
YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

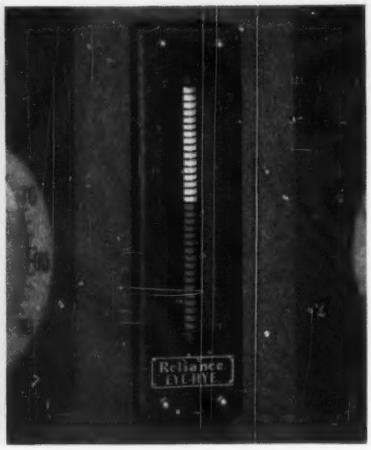
For more facts circle 275 on Reader Service card, p 123

Safe, sure check on boiler water levels with wide-vision EYE-HYE

The remote gage with liquid indication



EYE-HYE for pressures up to 600 psi



EYE-HYE for pressures up to 3000 psi

Put your boiler water level supervision on a plane with other power plant control facilities — read levels at your control station with Reliance EYE-HYE.

The dependable accuracy of this popular remote reading indicator eliminates "boiler-climbing"; its bright green liquid-column image stands out — mistake-proof. And EYE-HYE's improved design provides visibility over a wide arc — lower pressure models up to 90°; new higher pressure models, to 180°.

Simple manometric design, with no mechanical parts and no adjustments on location. Available with economical special attachment to actuate supplementary alarms . . . Write for catalog information on EYE-HYE for *your* boiler pressure.

The UNITEMP, complete temperature equalizing unit furnished with each EYE-HYE

1884 75th YEAR 1959

The Reliance Gauge Column Company

5902 Carnegie Ave. • Cleveland 3, Ohio

Equipment news

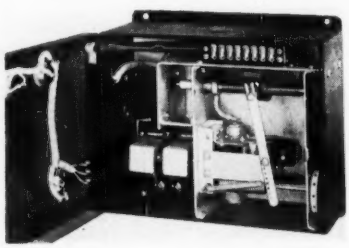
Begins on page 134

ation, delivers an average power output of 250 w and produces peaks of 1000 w. — National Ultrasonic Corporation

Disconnect-switch device

38 • Completely enclosed device for mounting on disconnect switches to interrupt currents of 600 amp and up to 34.5 kv operates efficiently even with more than ¾-in. coating of ice. Ice test demonstrated that both disconnect switch and interrupt device opened and closed successfully in frozen state, maker claims.—H K Porter Co, Delta-Star Electric Div

Just circle key numbers on the Reader Service card, page 123, to get complete product story

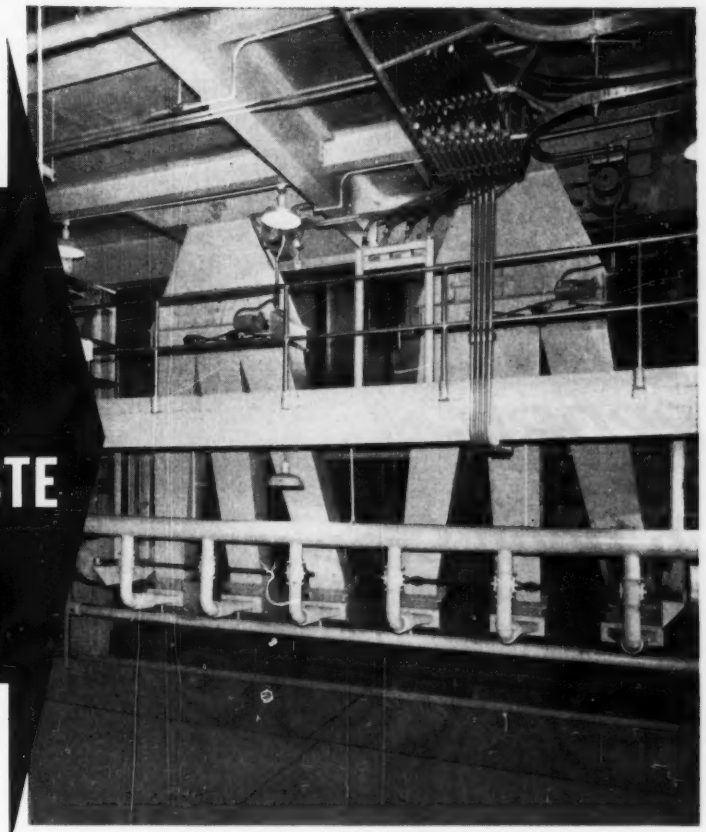


Master controller

22 • Fully automatic, heavy-duty sensing and controlling instrument for use with automatic combustion-control systems or comparable industrial applications responds to minute changes in pressure or temperature, transmits line-voltage signals to other system components for control of firing rate, damper positioning, valving or other regulation.

Models for controlling steam pressure are available in standard ranges of 0 to 30, 20 to 100 and 75 to 300

BOWATERS UTILIZES BY-PRODUCT WASTE AS FUEL



At Bowaters Carolina Corporation, Detroit RotoGrate Stoker, with 6 Detroit air swept spout refuse distributor feeders, installed under Babcock and Wilcox 2 drum single pass steam generator. Steam is produced at 850 psig, 900° F-T.T. Feedwater temperature 300° F. Combustion air temperature is 350° F.

Bowaters Carolina Corporation's new plant at Catawba, South Carolina uses a Detroit RotoGrate Stoker to burn bark refuse under a steam boiler. The installation is designed to produce 200,000 pounds of steam per hour when burning bark alone.

Costly waste disposal measures, which in years past were common to pulp mill operation, have been eliminated.

Provision is made for future firing of coal either in conjunction with bark or separately, and 275,000 pounds of steam will be produced with this combination. Peaks of 300,000 pounds of steam are anticipated.

Oil and gas burners in the furnace walls are presently used for auxiliary firing if refuse fuel is not available in sufficient quantity to supply the demand for steam.

Versatile in their ability to burn a broad variety of fuels . . .

DETROIT ROTOGRATE STOKERS

. . . have an established reputation for efficient performance.

8417

DETROIT STOKERS COST LESS: Cost equals initial investment plus upkeep plus production losses due to equipment outage. *The total is less with Detroit.*

DETROIT STOKER COMPANY

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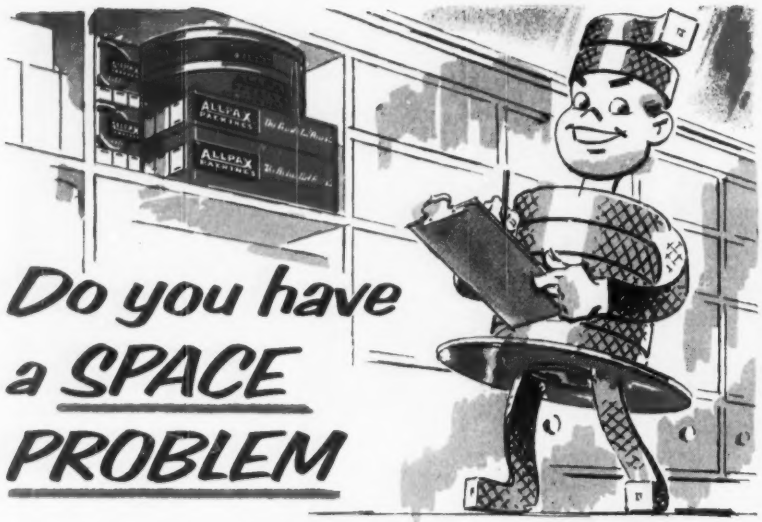


Do you have a SPACE PROBLEM in your Stockroom?

If your problem is space and inventory, Allpax has the answer. Allpax "Universal" Packings save valuable stockroom space and reduce inventories. Included in the complete line of Allpax mechanical packings are four basic, universal styles that will cover the majority of your requirements. Result: Less inventory required—more stockroom space available.

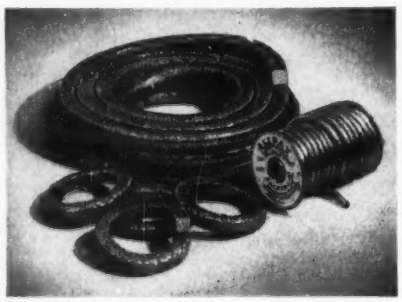
Allpax Styles 1, 2, 5, and 14 are "Packing Insurance" against steam, water, air, chemicals, acids, oils, etc., over a complete range of temperatures and pressures. Finest materials plus engineered construction are combined to produce our unbeatable, all-purpose packings that provide a tight seal without danger of scoring or unnecessary wear. Warranteed to be free from defects in materials and workmanship.

Allpax Universal Packings

- ✓ Save Valuable Space
- ✓ Reduce Inventories
- ✓ Simplify Ordering
- ✓ Reduce Downtime
- ✓ Cut Investment

Also: A complete line of Teflon* packing materials.

*DuPont Trademark



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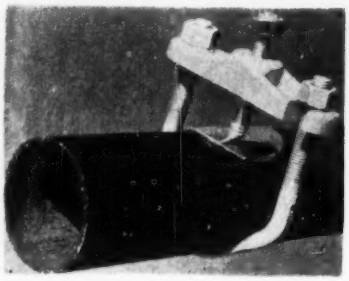
Equipment news

Begins on page 134

psi. Ranges above 300 psi are available on special order. — Cleveland Controls, Inc

Conveyor belting

24 • Rubber friction-surface belting is for use where woven duck, stitched canvas or other friction surface is now used. Belting has extra-thick skim coats of natural rubber to check wicking and block edge ravel. It has a nonstaining surface, is resistant to mild acids and is bright orange in color.—United States Rubber Company



Pipe patch

20 • This pipe-patching method repairs small leaks in any fluid or gas line by placing patch directly over the leak and applying pressure with a tool. Two types of "hold-down" clamps are available — saddle type for ¾- through 6-in. pipe (shown above) and chain type for 7- through 36-in. pipe.—M J Crose Manufacturing Co, Inc

Just circle key numbers on the Reader Service card, page 123, to get complete product story

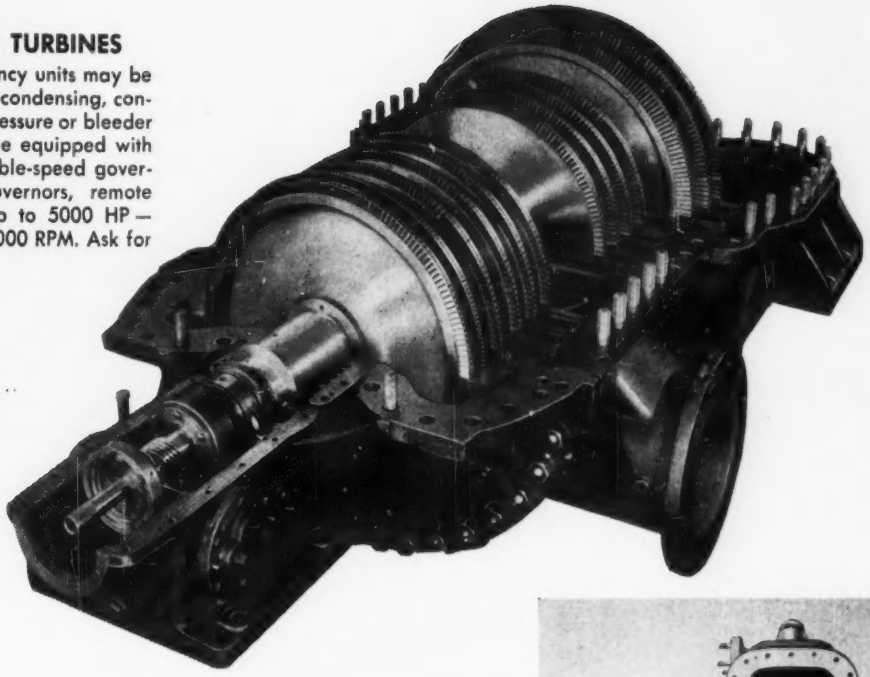
Insulating firebrick

35 • Insulating brick offers low thermal conductivity, can be fitted with hangers or pins without danger of breakage. Average weight is 1.70 lb per 9-in. straight.

Resistance to gas erosion, and mortar bonding which holds tightly are added features, says manufacturer. Firebrick can be cut, drilled or shaped as necessary. On-the-job cutting and shaping can even be done with ordinary wood-working tools.—The Babcock & Wilcox Company

MULTI-STAGE TURBINES

These high-efficiency units may be designed for non-condensing, condensing, mixed pressure or bleeder operation. Can be equipped with constant or variable-speed governors, special governors, remote controls. Sizes up to 5000 HP — Speeds up to 10,000 RPM. Ask for Bulletin S-146.



There's a **Terry turbine** for every mechanical-drive requirement

The designs for Terry turbines are based on more than 50 years of successful experience in the manufacture of turbine drives *exclusively*. This specialization has resulted in Terry becoming one of *the leading producers* of mechanical-drive turbines in sizes up to 5,000 horsepower.

There are three basic reasons why Terry has been able to maintain this position of leadership: (1) a thorough knowledge of the requirements of mechanical-drive turbines, (2) a willingness to build "a little something extra" into each machine to assure trouble-free operation, and (3) an acknowledgement of the company's responsibility to stand behind the performance of every turbine sold.

These are also the reasons why you should consider a Terry turbine for your next mechanical drive. In the meantime, send for bulletins describing any of the types of machines illustrated.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

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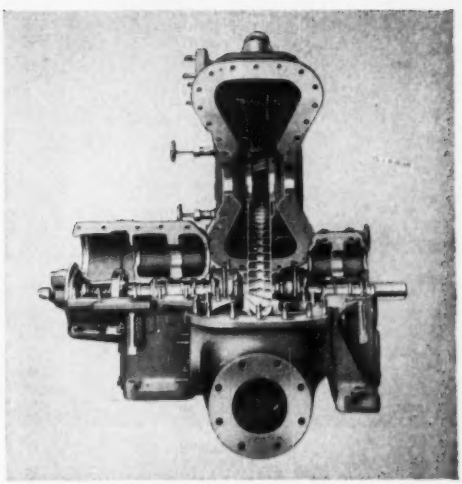
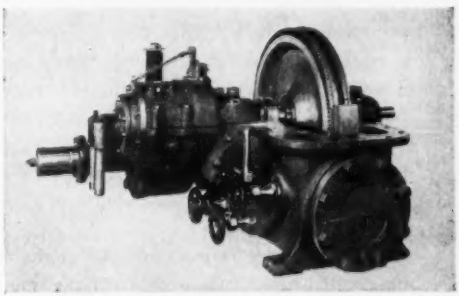


SOLID-WHEEL TURBINES

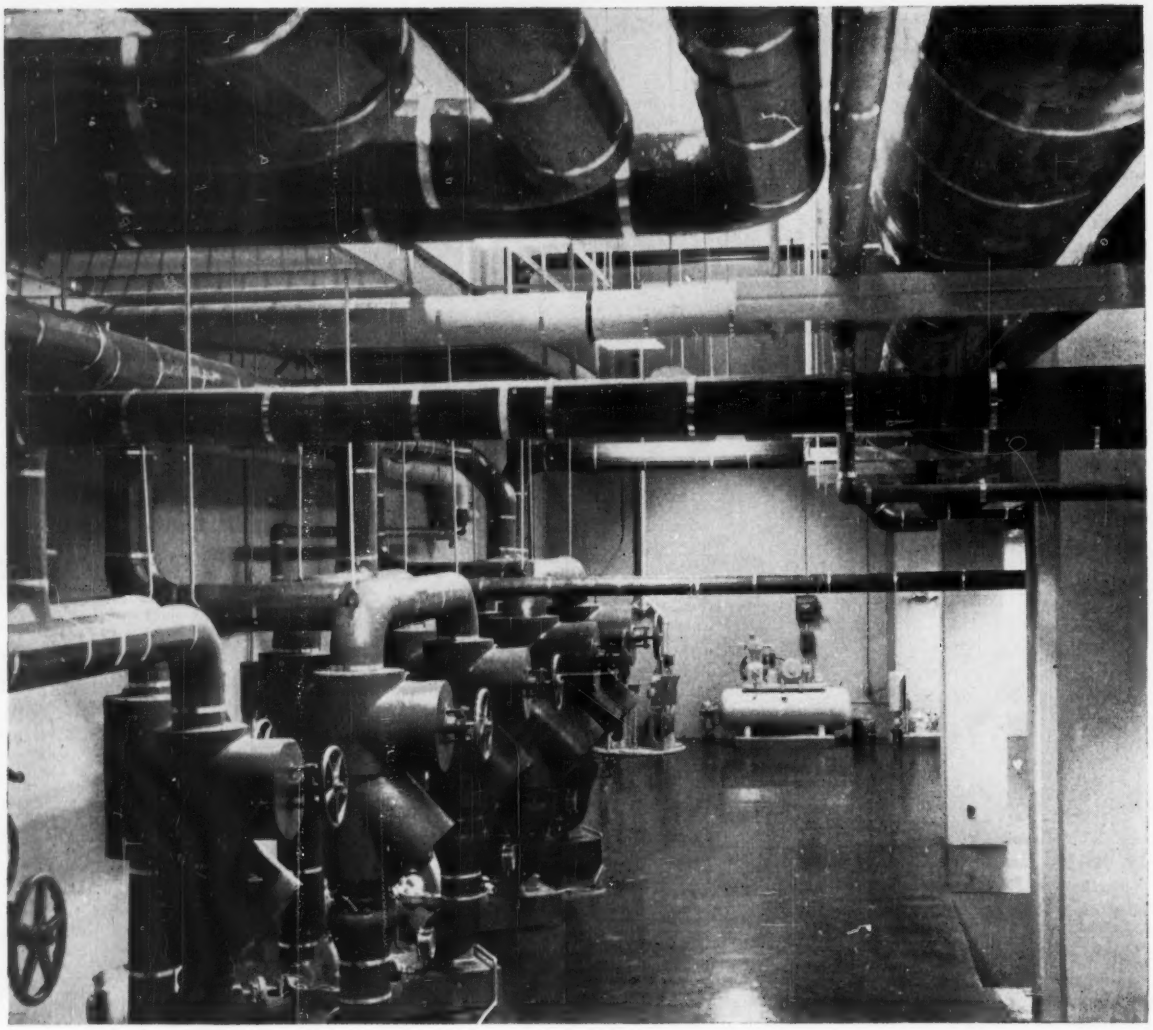
Famous for sure dependability and ease of inspection. Can be started cold — no preliminary warming required. Available in vertical designs depending on frame size. Capacities from 5 to 2,000 HP. Described in Bulletin S-116.



AXIAL-FLOW IMPULSE TURBINES

Built with one, two or three rows of high-grade stainless steel blading, these turbines combine efficiency with durability. Available in designs for moderate and high steam pressure. Bulletin S-143.

For more facts circle 279 on Reader Service card, p 123



Sure it's neat—but how can you tell it's safe?

The product tells you it's safe—USS National Seamless Steel Pipe and Tubes. The designer who insists on USS National Seamless is taking no chances. He wants to safeguard life and equipment, and to stop shutdowns because of unexpected failures.

Seamless shuts out all doubt. From end to end, it's one continuous piece of highest quality steel. No welds. No weaknesses. Absolute uniform wall strength. What's more, when a solid billet of steel is pierced, it's also critically explored. If the billet is successfully pierced, then every inch of the pipe is structurally sound.

Little wonder, then, that for industrial uses involving particularly severe or hazardous service, the first choice of engineers is seamless—in many cases, the use of seamless pipe is mandatory.

Remember this! USS National Seamless has ample ductility to permit bending, coiling and all other manipulations. USS National Seamless is not only the safest, but also the easiest to work with.

National Tube manufactures seamless pipe and tubes in a complete range of steel analyses from low carbon through the alloys up to and including stainless steel, to withstand the highest pressures and temperatures. A wide variety of sizes and wall thicknesses is available. Plan now to contact National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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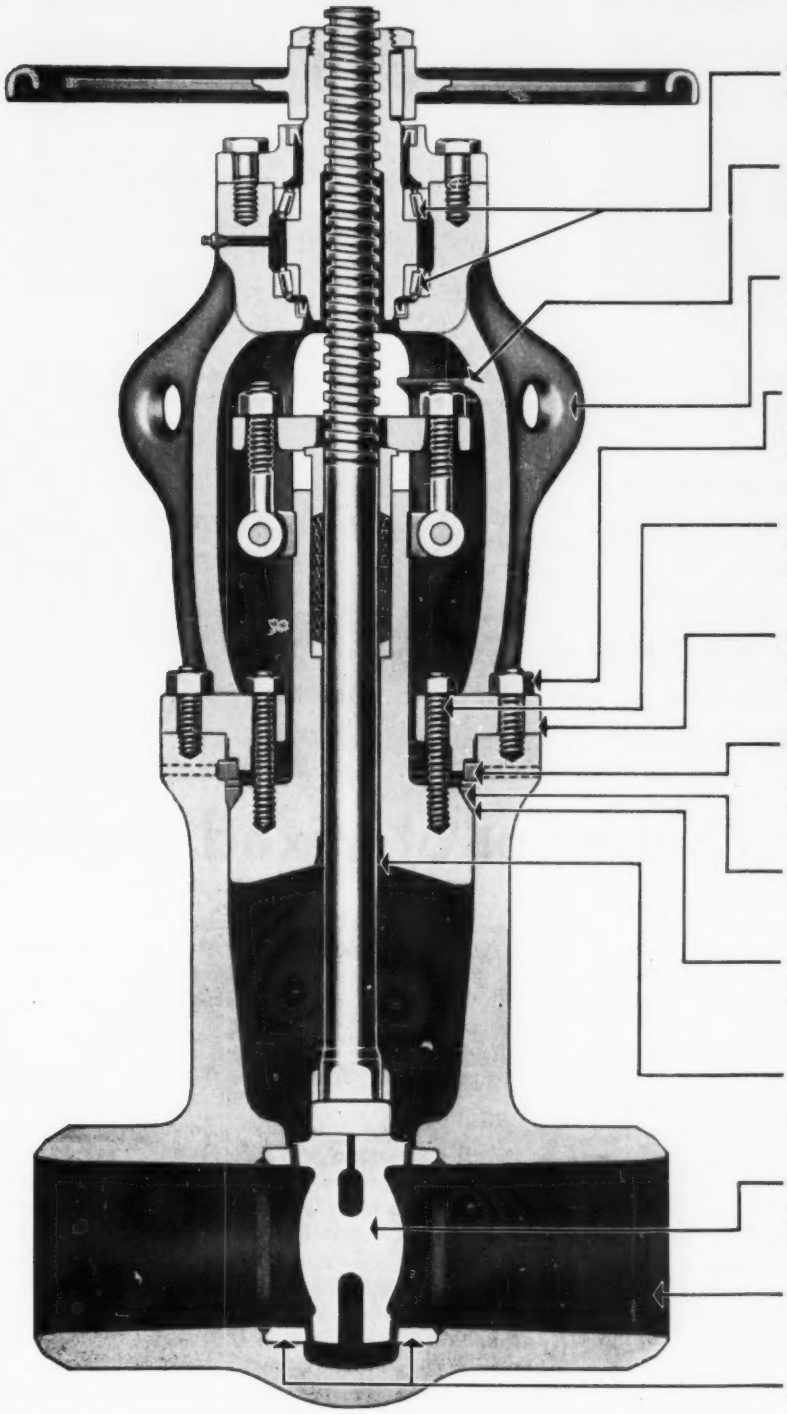
POWELL PRESSURE SEAL VALVES

GATE, GLOBE, ANGLE and CHECK PATTERNS
Pressure Classes . . . 600, 900, 1500, 2500 Pounds and Higher . . . ALL COMMERCIAL SIZES



Tapered roller bearings are most satisfactory for high thrust loads.

Lugs on the inner side of yokearms provide a convenient shelf for suspending gland flange when renewing packing.

Lifting lugs facilitate handling the valve during erection and maintenance. Also provide means for supporting weight of the valve.

Body studs hold the yokearm to the body. These eliminate the need of a heavy clamp, and maintain perfect alignment and rigidity of yoke to the body.

Bonnet studs are used to establish the initial seal of the gasket between the body and the bonnet.

Streamline contour of body simplifies application and reduces cost of insulation, and effects marked savings in space and weight.

Segmental thrust ring absorbs all the thrust applied by internal pressure. This design enables valve to be easily assembled and disassembled.

The gasket may be removed without damage to seating surface of body.

The gasket seating surface in the body may be easily lapped, if required—an outstanding feature in Powell Pressure Seal Valve design.

Stellite faced back seat and stem guide insure tight sealing, accurate guiding of stem and protects packing when valve is back seated.

Flexible "H"-type wedge, which is stellited, prevents sticking because of temperature changes and pipe line stresses, thus reducing opening torque.

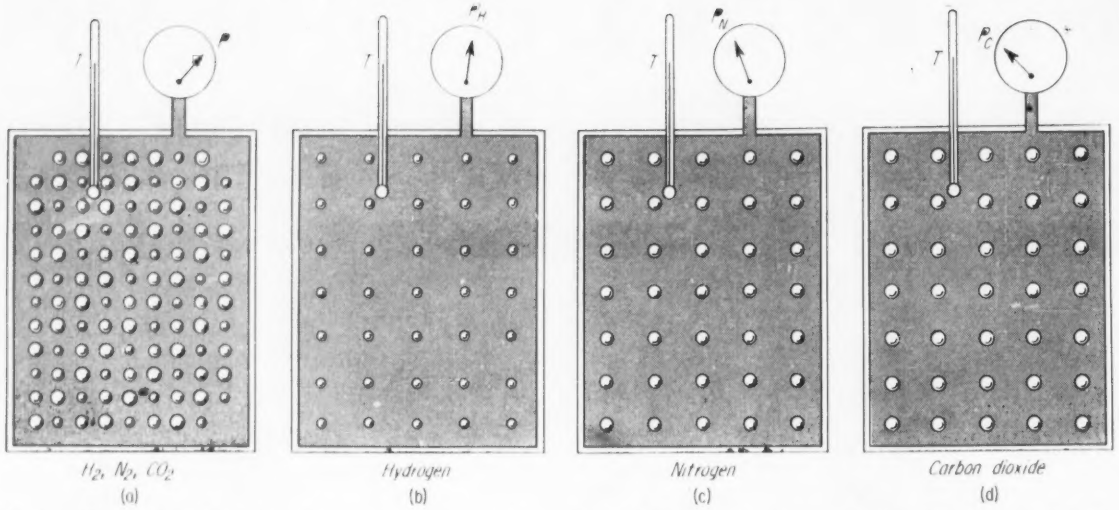
Streamlined passage makes possible maximum flow with minimum turbulence.

Seat Rings are stellite faced, accurately machined and welded in place.

(Sectional) PRESSURE SEAL GATE VALVE

THE WM. POWELL COMPANY • *Dependable Valves Since 1846* • **Cincinnati 22, Ohio**

For more facts circle 281 on Reader Service card, p 123



1 According to Dalton's law the total pressure P exerted by a gas mixture as in (a) is the sum of the partial pressures of the individual gases (b), (c) and (d) when they are all at the same temperature and held in the same total volume of container

THERMO REFRESHER NO. 33

By B G A SKROTZKI, Associate Editor

Most engines work with mixtures of gases and vapors. So far we have assumed they all work with air to make the studies simple. Now we'll learn . . .

How to figure behavior of mixed gases

We used air as the working fluid in studying power cycles. This assumed that air is a gas with specific characteristics relating pressure, temperature, density, internal energy, enthalpy, specific heat and entropy. Actually, air is a mixture of gases: nitrogen, oxygen, carbon dioxide, argon and some rare elements.

In many practical problems, especially combustion, we must deal with gas and gas-vapor mixtures. We have a host of data on individual gas elements and we can combine them to figure the characteristics of any mixture. Here we'll deal only with gas mixtures.

Avogadro's law. In Part 4, Nov 1956, we learned this law said *Equal volumes of perfect gases held under exactly the same temperature and pressure have equal numbers of molecules.*

For this condition the masses or densities of equal volumes of gas are in proportion to their molecular weights, for instance:

$D_H : D_N : D_C = 2.02 : 28.0 : 44.0$

where D_H = density of hydrogen, D_N = density of nitrogen, D_C = density of carbon dioxide, all in lb per cu ft.

We also learned this leads to a universal gas constant $R_u = 1545$ and individual gas constants can be figured from $R = R_u/M$ where M is the molecular weight of the gas with the gas constant R. Using the three gases above as an example:

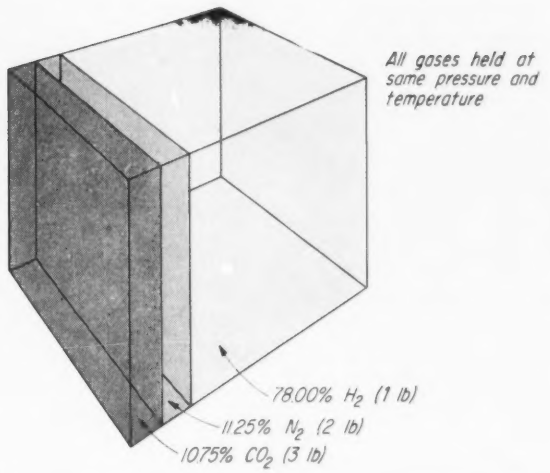
$$R_H = \frac{1545}{2.02} = 765; \quad R_N = \frac{1545}{28.0} = 55.2;$$

$$R_C = \frac{1545}{44.0} = 35.2$$

We met the *mole volume*, $V_M = MV$ where V is the gas specific volume, cu ft per lb. This can be used in the perfect-gas equation: $PV_M = R_uT$. In Part 4 we also showed that a mole volume (mole, for short) of any gas at 2116-psf pressure and 492 °R temperature is 359.2 cu ft. Reducing gas quantities to moles simplifies calculations.

Gibbs-Dalton law. Back in 1802 Dalton, a chemist, postulated the law about gas mixtures that said, in effect, *Gases occupying a common volume each fill that volume and behave as if the others were not present,* Fig. 1*a*.

With this as a basis let's first recognize that the total mass of the mixture is the sum of the individual gas masses: $m_t = m_H + m_N + m_C$, using the three gases above.



2 Heavier gases occupy much smaller volume than lighter gases for each lb when they are at same pressure and temperature

Each gas occupies the same total volume by definition so:

$V'_t = V'_H = V'_N = V'_C$

Relating this to the gas specific volumes:

$V'_t = m_H V_H = m_N V_N = m_C V_C$

What about the temperature of the mixture? Since molecules must slam into each other at random, they exchange energy quickly and so average out the total energy in the mixture. This means that the gases all come to a common temperature so that:

$T = T_H = T_N = T_C$

According to Dalton's law each gas must exert its own pressure which can be figured as:

$$P_H = \frac{R_H T}{V_H} = \frac{R_H T}{V'_t/m_H}; \quad P_N = \frac{R_N T}{V_N} = \frac{R_N T}{V'_t/m_N}$$

$$P_C = \frac{R_C T}{V_C} = \frac{R_C T}{V'_t/m_C}$$

With each gas pounding against the container walls the total pressure must be:

$$P = P_H + P_N + P_C$$

$$= \frac{T}{V'_t}(m_H R_H + m_N R_N + m_C R_C)$$

$$= \frac{R_u T}{V'_t}\left(\frac{m_H}{M_H} + \frac{m_N}{M_N} + \frac{m_C}{M_C}\right)$$

These last equations sum up the first part of the Gibbs-Dalton law: *The pressure of a gas mixture is the sum of the pressures that each gas would exert if it alone occupied the volume.*

The second part of the Gibbs-Dalton law can be taken as a basic definition: *Properties of a gas mixture are equal to the sums of those properties for each component when it occupies the total volume by itself; these properties are internal energy, enthalpy and entropy.*

Remembering that E = internal energy in Btu per lb, then: $m_t E = m_H E_H + m_N E_N + m_C E_C$

Letting h = enthalpy in Btu per lb, we have:

$m_t h = m_H h_H + m_N h_N + m_C h_C$

Remembering that S = entropy, Btu per lb-F

$m_t S = m_H S_H + m_N S_N + m_C S_C$

Letting c = specific heat of a gas at either constant pressure or at constant volume, then:

$m_t c = m_H c_H + m_N c_N + m_C c_C$

Best way to learn how to use these equations and appreciate some of the relationships is in an example.

Example: A 10-cu-ft tank holds 1-lb H_2, 2-lb N_2 and 3-lb CO_2 at 70 F. Find the specific volume, pressure, specific enthalpy and specific entropy of the individual gases and of the mixture, and the mixture density.

$V_H = 10/1 = 10.00$ cu ft per lb

$V_N = 10/2 = 5.0$ cu ft per lb

$V_C = 10/3 = 3.33$ cu ft per lb

$V_t = 10/(1 + 2 + 3) = 1.667$ cu ft per lb

Using $R = R_u/M$

$$P_H = \frac{1545 \times 530 \times 1}{10 \times 2.02} = 40{,}530 \text{ psfa}$$

$$P_N = \frac{1545 \times 530 \times 2}{10 \times 28} = 5850 \text{ psfa}$$

$$P_C = \frac{1545 \times 530 \times 3}{10 \times 44} = 5583 \text{ psfa}$$

$P_t = 40{,}530 + 5850 + 5583 = 51{,}963$

From Keenan and Kaye *Gas Tables* find:

$h_H = 1796.1$ **Btu per lb**

$h_N = 131.4$ Btu per lb

$h_C = 90.17$ Btu per lb

$mh = 1 \times 1796.1 + 2 \times 131.4 + 3 \times 90.17 = 2329.4$ Btu

$h = 2329.4/(1 + 2 + 3) = 388.2$ Btu per lb mixture

From *Gas Tables* find internal energy:

$E_H = 1260.0$ Btu per lb

$E_N = 93.8$ Btu per lb

$E_C = 66.3$ Btu per lb

$mE = 1 \times 1260.0 + 2 \times 93.8 + 3 \times 66.3 = 1646.5$ Btu

$E = 1646.5/(1 + 2 + 3) = 274.4$ Btu per lb mixture

From *Gas Tables* find entropies:

$S_H = 12.52$ Btu per lb-F

$S_N = 1.558$ Btu per lb-F

$S_C = 1.114$ Btu per lb-F

$mS = 1 \times 12.52 + 2 \times 1.558 + 3 \times 1.114 = 18.978$

$S = 18.978/(1 + 2 + 3) = 3.163$ Btu per lb-F mixture

Density of gas mixture can be readily figured from the specific volumes of the components by applying Dalton's law (density is the reciprocal of specific volume):

$$D_t = D_H + D_N + D_C \text{ or } \frac{1}{V_t} = \frac{1}{V_H} + \frac{1}{V_N} + \frac{1}{V_C}$$

$$D_t = \frac{1}{10.0} + \frac{1}{5.0} + \frac{1}{3.33} = 0.6 \text{ lb per cu ft of mixture}$$

This checks with the first calculation, $V_t = 1.667$ cu ft per lb, and is based on the principle that all gases occupy the same volume.

Volumetric analysis. In analyzing gases we often want to make a volumetric analysis of a mixture. This assumes that each gas is held in a volume at the pressure and temperature of the mixture. Fig. 2 shows one way of analyzing the problem. Total volume holding the final mixture has its interior divided by partitions so that each component gas has the same pressure and temperature as the final mixture. Then for each gas:

$PV = R_u T/M$ and $V = R_u T/MP$

Using the three gases in the above example the total volume for each gas component in the mixture is:

$$m_H V_H = m_H \frac{1545T}{M_H P}; \qquad m_N V_N = m_N \frac{1545\,T}{M_N P}$$

$$m_C V_C = m_C \frac{1545\,T}{M_C P}$$

The total volume of the mixture is:

$$V_T = \frac{1545\,T}{P}\left(\frac{m_H}{M_H} + \frac{m_N}{M_N} + \frac{m_C}{M_C}\right)$$

The percentage of each component in the mixture by volume (using H as an example) is:

$$\%V_H = \frac{\frac{1545\,T}{P}\left(\frac{m_H}{M_H}\right) \times 100}{\frac{1545\,T}{P}\left(\frac{m_H}{M_H} + \frac{m_N}{M_N} + \frac{m_C}{M_C}\right)}$$

$$= \frac{\frac{m_H}{M_H}}{\frac{m_H}{M_H} + \frac{m_N}{M_N} + \frac{m_C}{M_C}} \times 100$$

$$= [(m_H/M_H)/\Sigma(m/M)] \times 100$$

Then the *volumetric analysis* of the gas is:

$$\%V_H + \%V_N + \%V_C = 100$$

Weight analysis. The gravimetric or weight analysis can be figured from total weight or mass of mixture:

$$m_T = m_H + m_N + m_C$$

Then the weight analysis is:

$$\%m_H = \frac{m_H}{m_T} \times 100; \qquad \%m_N = \frac{m_N}{m_T} \times 100;$$

$$\%m_C = \frac{m_C}{m_T} \times 100$$

and $\%m_H + \%m_N + \%m_C = 100$

Molal analysis. We can analyze the makeup of a gas in terms of the number of moles of each gas in the mixture. Referring to Part 4, Nov 1956, p 92, we recall that one mole of H_2 weighs M lb or 2.02 lb, one mole of N_2 weighs 28.0 lb and one mole of CO_2 weighs 44.0 lb.

Then to find the number of moles n of a gas we need only to find m/M ratio for it in a mixture. The total moles in the mixture are:

$$n_t = (m_H/M_H) + (m_N/M_N) + (m_C/M_C) = \Sigma\,(m/M)$$

The percentage of each component in the mixture by moles using H_2 as an example is:

$$\%n_H = [(m_H/M_H)/\Sigma(m/M)] \times 100$$

This is the same as the percentage analysis of the gas by volume, so the two methods are identical.

Now let's try out some of these formulas for the gas mixture we had in the previous example.

Example: First let's check total volume of 6-lb gas:

$$V_t = \frac{1545 \times 530}{51{,}963}\left(\frac{1}{2.02} + \frac{2}{28.0} + \frac{3}{44.0}\right)$$

$$= 10.0 \text{ cu ft for 6 lb of gas mixture.}$$

Expanding the fractions in the parentheses we get:

$$\Sigma(m/M) = 0.495 + 0.0714 + 0.0682 = 0.6346$$

Then: $\%V_H = (0.495/0.6346) \times 100 = 78.00$

$\%V_N = (0.0714/0.6346) \times 100 = 11.25$

$\%V_C = (0.0682/0.6346) \times 100 = 10.75$

Total 100.00%

As we just learned, this analysis is the same for the molal distribution. Weight analysis can be quickly figured:

$\%m_H = (1/6) \times 100 = 16.67$

$\%m_N = (2/6) \times 100 = 33.33$

$\%m_C = (3/6) \times 100 = 50.00$

Total 100.00%

The analyses vary considerably percentagewise; let's summarize the quantities in the mixture:

Gas	*m, lb*	*M, no.*	*V, ft³/lb*	*MV*	*%V*	*%m*
H_2	1	2.02	7.81	15.77	78.00	16.67
N_2	2	28.00	0.563	15.77	11.25	33.33
CO_2	3	44.00	0.3585	15.77	10.75	50.00

Inspect these values, keeping in mind that they hold for a temperature of 70 F or 530 °R and a pressure of 51,963 psfa or 360.7 psia, when the gases are compartmented according to their volume as in Fig. 2.

When the gases occupy total common volume of 10 cu ft we summarize the data as:

Gas	*m, lb*	*M, no.*	*V, ft³/lb*	*D, lb/ft³*	*P, psia*	*%m*
H_2	1	2.02	10.00	0.10	281.3	16.67
N_2	2	28.00	5.00	0.20	40.6	33.33
CO_2	3	44.00	3.33	0.30	38.8	50.00
Total	6		1.67	0.60	360.7	100.00

In the transparent box of Fig. 2 suppose we remove partitions and allow the gases to mix. What happens? Each gas expands into the full 10-cu-ft volume and since the expansions are adiabatic and no work is done the temperature remains the same for all gases. This means their individual internal energies and enthalpies also remain constant. But each of their total pressures of 360.7 psia in the separated state drops to their partial pressure in the mixed state.

The gas expansions imply that a theoretical opportunity for doing work has been lost even though the temperature has stayed constant. Each gas could do work against a piston as it expands.

This loss of availability comes to light when we study the entropy changes of the gases while expanding. In Part 10, July 1957 we learned that the change in entropy for a process was $S_2 - S_1 = Q/T$; for a constant-temperature process this can be shown to reduce to:

$$S_2 - S_1 = \frac{mR}{J}\log_e\frac{V_2}{V_1}$$

Then for each of the gases in the example:

$$S_H = \frac{1.0 \times 1545}{778 \times 202}\log_e\frac{10.0}{7.81} = 0.243 \text{ Btu per F}$$

$$S_N = \frac{2.0 \times 1545}{778 \times 28.0}\log_e\frac{5.0}{0.563} = 0.3097 \text{ Btu per F}$$

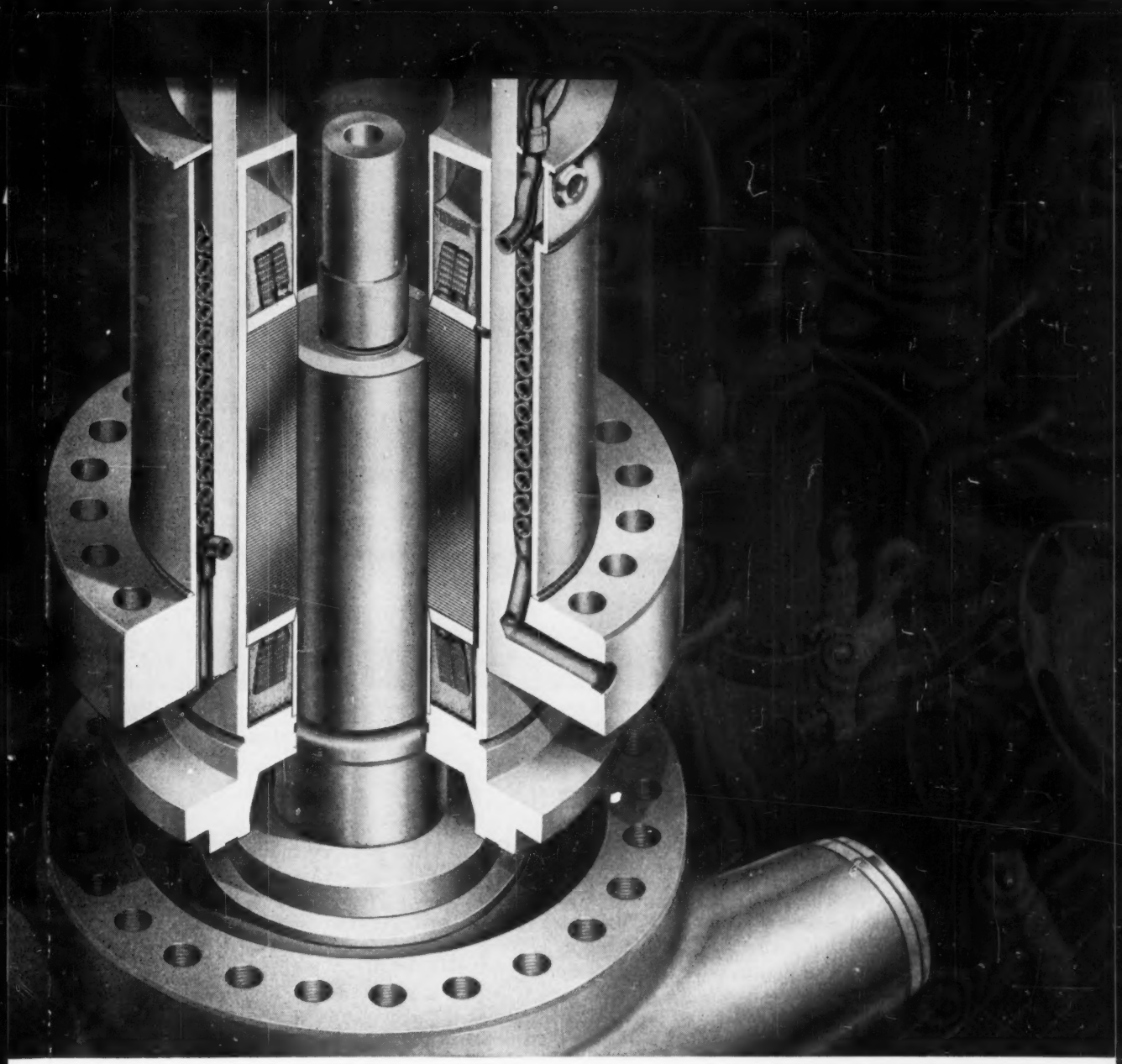
$$S_C = \frac{3.0 \times 1545}{778 \times 44.0}\log_e\frac{3.33}{0.358} = 0.3017 \text{ Btu per F}$$

So when we remove the partitions between the gases in Fig. 2 and let them mix, the overall temperature and pressure do not change but the entropy increases by:

$S_H + S_N + S_C = 0.243 + 0.3097 + 0.3017 = 0.8544$ Btu per F, or: $0.8544/6 = 0.1424$ Btu per lb-F.

This demonstrates that mixing gases, even without change in temperature and pressure, is an irreversible process. To separate the molecules of gas in a mixture would require individual work on each to recompartment them in the separate state.

An interesting question arises when the compartments in Fig. 2 all hold the same gas at a common temperature and pressure. When we remove the partitions from the closed container the molecules diffuse among each other. Is this an irreversible process? No—because we re-create an identical condition when we reinsert the partitions; though the molecules are different, they are all of the same kind. This is the *Gibbs paradox*.



New Removable Stator Design, "Canned" Motor-Pump (exploded cutaway view)

For better boiler circulation...specify Westinghouse "canned" motor-pumps

Controlled circulation boilers equipped with Westinghouse "canned" motor-pumps have a higher unit efficiency, are more reliable and are easier to operate and maintain.

The pump and motor casings completely enclose the pump shafting... Conventional shaft seals and complicated seal injection systems are eliminated.

Watertight Inconel cans encase the rotor and stator . . . All windings are dry and clean for years of trouble-free operation.

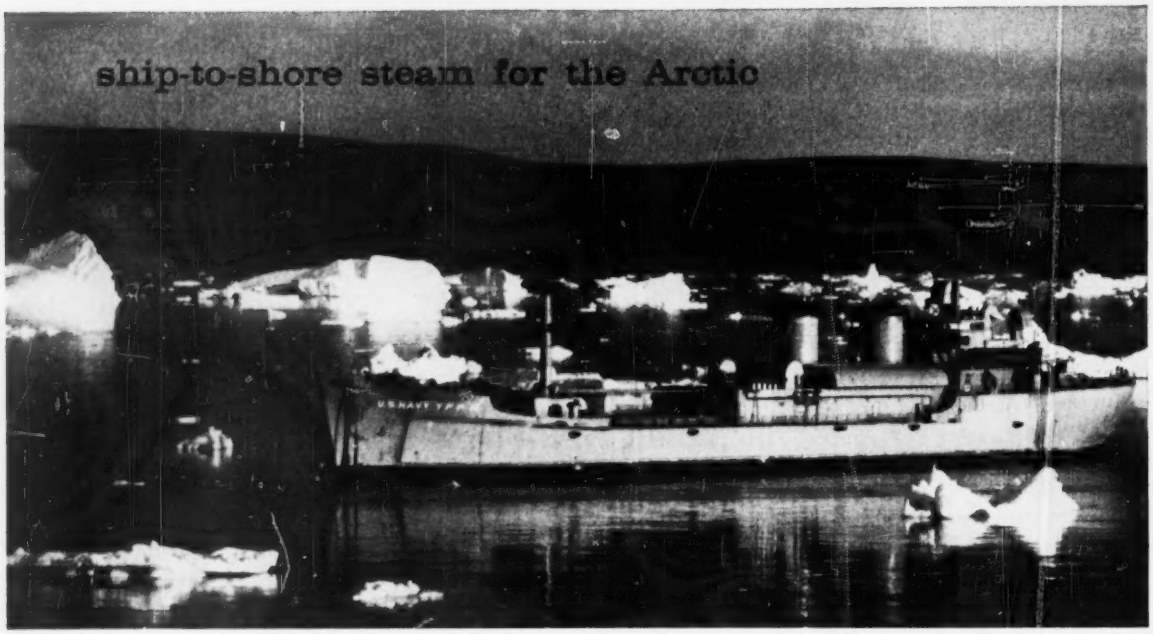
New unit construction of stator and rotor permits easy, fast (24-hour), in-your-shop inspection, overhaul and repair... Reliability and availability of pumps are at a maximum.

For more information on how Westinghouse "canned" motor-pumps will improve controlled circulation boiler performance, contact your Westinghouse sales engineer, or write Westinghouse Electric Corporation, Atomic Equipment Department, P. O. Box 217, Cheswick, Pa. J-57011

YOU CAN BE SURE...IF IT'S Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

For more facts circle 282 on Reader Service card, p 123



CO-OPERATION — U.S. Army Engineers' Eastern Ocean District converted this Navy Floating Power Plant for the Arctic. Contractor — Bethlehem Steel Co.; consulting engineers — Metcalf and Eddy; and Reynolds, Smith and Hills. Military Sea Transportation Service towed it to northern Greenland where it will serve as part of the Ballistic Missile Early Warning System. (Photo credit, U.S. Navy)

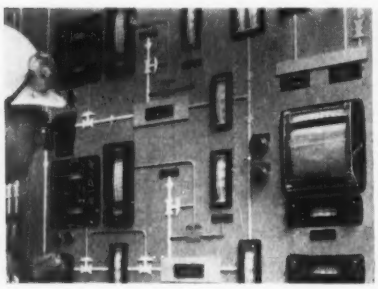
Foxboro controls "export" steam for unique Air Force floating power plant

A seagoing cargo vessel converted to a modern, shore-type steam-electric power plant. That's the YFP-10, designed for the Air Force — and floated to a site off northern Greenland where it will produce steam and power for the Ballistic Missile Early Warning System.

The YFP-10 can produce up to 135,000 pounds of export steam per hour. All steam temperature and pressure variables are under Foxboro control. Consotrol* control stations on the panel — Foxboro indicating pressure and temperature transmitters, and Foxboro valves on the line. Accurate, dependable, low-maintenance instruments — ideal for applications where top performance is critical.

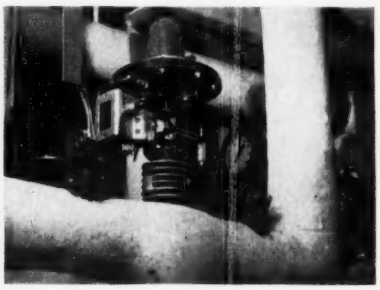
Afloat or ashore, nuclear or conventional — there's advanced Foxboro instrumentation for any power plant. Ask your nearby Foxboro Field Engineer for full details. Or write The Foxboro Company, 6812 Neponset Ave., Foxboro, Mass.

*Reg. U.S. Pat. Off.



Foxboro Graphic Panel controls pressures and temperatures of steam "exported" from YFP-10. Instrument at right is Consotrol Recorder with Controller integrally mounted at rear. Complete control station pulls out like a drawer, making all adjustments and component parts easily accessible.

Foxboro M/44 Transmitters monitor both export steam temperatures and pressures aboard the YFP-10. Direct-connected, 4-inch indicators continue to give measurements even in event of instrument air failure.



Final operators on the YFP-10's export steam system are all Foxboro valves equipped with high-speed, super-response Vernier Valvactors*. Valvactors eliminate any problem of stem or plug friction, valve motor or transmission line lag.

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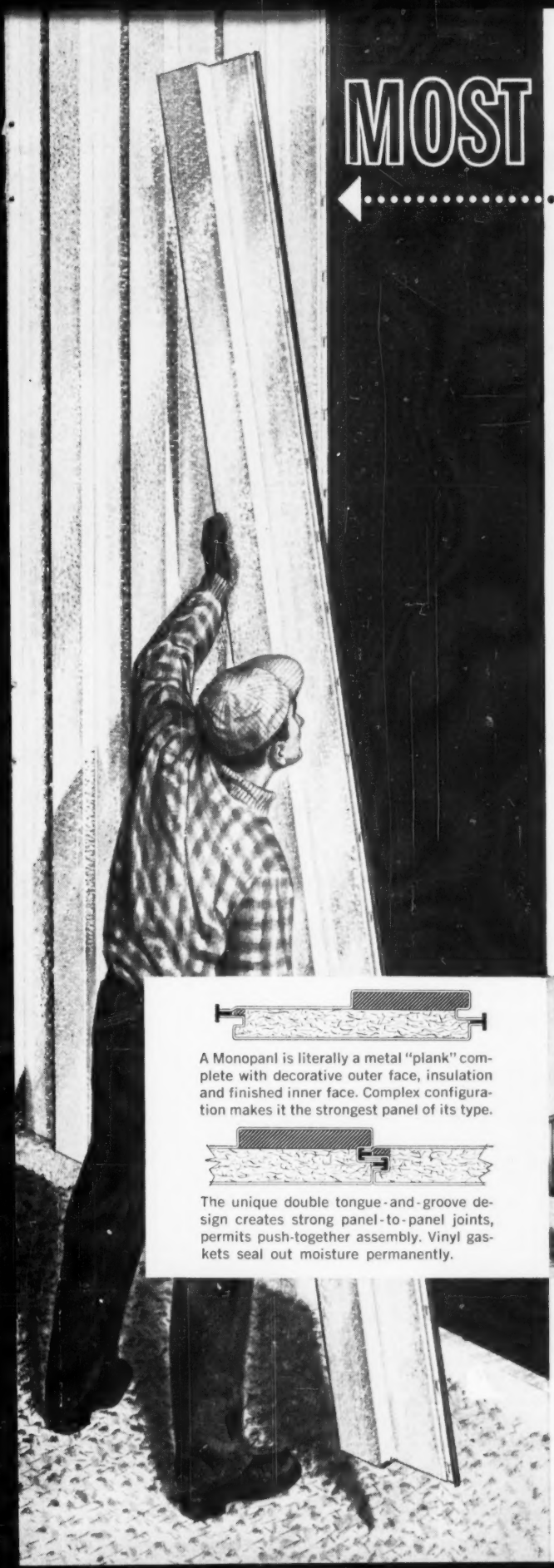


MOST ADVANCED

insulated curtain wall of its type

and it's brand new on Butler buildings

Here's a fellow that's literally making construction history. In one simple operation he's erecting a complete exterior wall, finished inside and out—fully insulated—and ready for use as installed.

This revolutionary advance in curtain wall construction is made possible with new Butler Monopanl. It is the first factory-fabricated, factory-insulated panel that is factory sized to fit a pre-engineered structural system . . . and it is exclusive on Butler buildings.

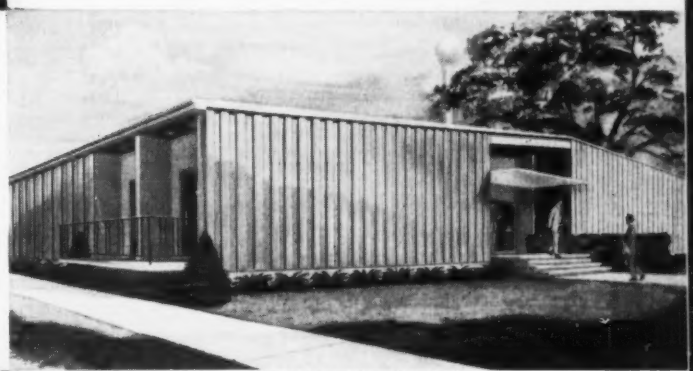
Today, even the largest Butler buildings can be enclosed in just days with handsome, slender—space-saving—curtain walls that permanently seal out weather and are equal in insulating ability to thick masonry.

Now, with new Monopanl, the Butler system of building is an even faster, better way to build . . . more than ever, the lowest-cost way to build well.

Call your nearby Butler Builder for full details. Ask him about Butler financing, too. He's listed in the Yellow Pages under "Buildings" or "Steel Buildings." Or write:

A Monopanl is literally a metal "plank" complete with decorative outer face, insulation and finished inner face. Complex configuration makes it the strongest panel of its type.

The unique double tongue-and-groove design creates strong panel-to-panel joints, permits push-together assembly. Vinyl gaskets seal out moisture permanently.



from a design by A. Francik and Associates, Architects

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circle 284 on Reader Service card, p 123

"They were monsters. Saliva drooled from their fangs as they tried to get at me."

Marmy goes to the dogs

O'Houlihan's Machine Shop & Engine Works had just knocked off for coffee. The shop was busy overhauling a hundred-ton, angle ammonia compressor when I dropped in yesterday. Machine had been ripped apart and the large crankshaft was dangling on chain falls.

Good thing I looked inside the shop before climbing the wooden steps to the old consulting engineer's office above, for there was Marmaduke Surfaceblow slurping coffee while talking with O'Houlihan. Stepping inside past the horizontal boring mill, I joined the party to see what was going on.

"It takes a lot of know-how to overhaul one of these old babies," I commented, hoping it would make Marmy sound off. "I'll bet you've operated many of these large compressors in your day, eh, Mr Surfaceblow?"

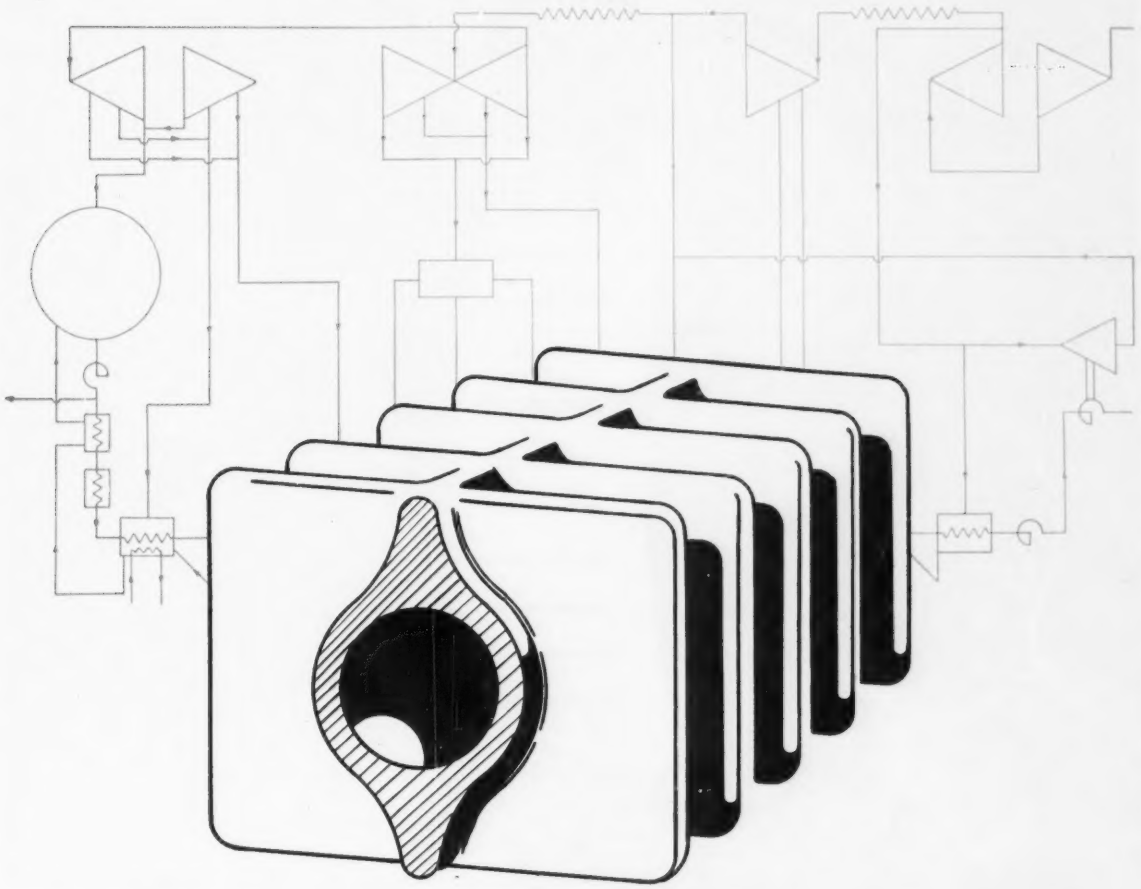
"BILGEWATER on operating compressors," roared the cantankerous engineer in his foghorn voice. "I'll tell you dial twiddlers about the time I sold a complete refrigeration plant. But I had to outsmart two ferocious dogs to do it."

Having gotten that off his chest, Marmy lit up a new piece of rope yarn and sent a cloud of No. 4 Ringelmann smoke screen in my direction. I coughed, wiped my eyes, then sat down on a packing case. So did O'Houlihan as he handed me a cup of coffee. Marmy hooked his thumbs into the armpits of his checkered vest and blasted away again. The mechanics gathered around.

"Back in 1912 I was chief engineer of the round-the-world *SS Robert Dollar*," roared Marmy. "She was a coal-burning twin-screw triple-expansion queen, the flagship of the Dollar Steamship Co. In those days, running a ship's plant was a blood, sweat and tears job. But we found enough excitement in port to make up for our headaches at sea—and then some.

"One evening while sailing along the island of Sumatra in the Indian Ocean, I was leaning over the railing and chewing the fat with a passenger. It was a balmy evening and Arnold Tetzlaff was in a talkative mood. He manufactured industrial refrigerating equipment in San Francisco and was on his way to Bombay. Said he was impressed with what he saw of the way I ran my engine room when I took him on a tour that morning.

"Tetzlaff then got back to his business and told me about a prospect in the States he couldn't sign up. There were too many roadblocks. 'I'm afraid I can't get to first base,' he complained, 'although it's almost in my back yard. I want that deal badly. Fact is, I'll give $2000 commission to the guy who nails it down.' That number interested me so I asked him to



Green's Low-Level Economizer belongs on your steam cycle flow diagram!

Why has Green's Low-Level Economizer already been purchased for inclusion in several large units scheduled for operation in 1960, 1961 and 1962?

1. It is accepted that low-level heat recovery offers the most economic method of obtaining the lower heat rates required today.

2. Flue gas-to-water heat exchange transfers the low temperatures from the airheater to the Low-Level Economizer where the problems of corrosion and plugging can be adequately resolved.

Green has had over 100 years of economizer experience. It is yours for the asking.

Green

THE GREEN FUEL ECONOMIZER CO., INC.

BEACON 3, NEW YORK

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any way you look at it...

YARWAY REMOTE LIQUID LEVEL INDICATOR GIVES BRIGHT, INSTANT, ACCURATE READINGS

On its brilliant "wide vision" dial you can clearly read the level from any point in a 180° arc—and from a considerable distance.

Remote readings of levels in boilers, feed water heaters and other heat exchangers are instant and accurate because indicator operating mechanism is actuated by the varying head of the liquid itself, yet the pointer mechanism is never under pressure.

Yarway Indicators may be arranged to operate remote Yarway Electronic Secondary Indicators or remote Hi-Lo Alarm Signals (lights or horns) located anywhere in the plant.

A record of nearly 13,000 successful installations speaks for itself.

For details on construction, operation, installation and typical hook-ups, write for Yarway Bulletin RI-1825.

YARNALL-WARING COMPANY
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BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING

For more facts circle 286 on Reader Service card, p 123

Begins on page 154

fill me in on the background. Here's the story Arnold Tetzlaff told me:

"An old meat packer in San Gabriel, California was building a new packing plant. He was spending about $200,000 for the buildings and machinery, which was a lot of cabbage in those days. But old Fritz Shellhamer the packer was an eccentric and a hermit to boot. The old geezer had suffered a stroke and was confined to a wheel chair. He was barricaded inside his big estate up in the hills of San Gabriel. The place had a high stone wall around it and two ferocious German police dogs kept guard inside. They were mostly wolf and were ready to tear anyone limb from limb.

"Story was that Shellhamer had become suspicious of outsiders since being taken by a con man a few years before. So to keep people away, he even had his telephone ripped out.

"Only communication Shellhamer had with the outside world was through his nephew, who ran the show. But that drip was a good-for-nothing playboy. The old man wouldn't trust the kid with his cash, so he was putting it all into his new plant so the jerk wouldn't squander it in one shot. But that useless squirt was taking the old gent for a sleigh ride anyway by getting a rakeoff on everything he bought at jacked-up prices. Fast-talking salesmen were wining and dining the playboy in Los Angeles. Then they'd sign him up for equipment that didn't even belong in a packing plant.

"Tetzlaff said the old man had a good reputation as a meat packer. He also knew something about refrigeration. But the old boy was living more and more in the past, with his young heir just waiting for him to croak. Because Tetzlaff was honest and wouldn't boost his prices to give the kid a rakeoff, that useless buffoon wouldn't even talk with him.

" 'If I could only sit down face to face with that old goat for a few minutes,' complained Tetzlaff. 'I know I could put him straight. Hell, he's spending enough money to build the finest plant on the West Coast. But how do you get to see a hermit who's walled in, guarded by two man-eaters, and constantly watched by a conniving, money-hungry devil of a nephew?'

" 'We'll reach the West Coast in a few months,' I suggested. 'Suppose you brief me on your plans. Make me some sketches so I can lay them before the old gent. I just might get to see him. Anyway, I'm willing to try. That $2000 looks mighty good to me.'

"For the next few days Arnold and I went over sketches and figures based on what he had learned of the new plant's requirements. We worked out a chilled-brine system with evaporation. The machines were to be direct-connected ammonia compressors. By the time Arnold got off in Bombay, I had all the plans, answers and prices.

"Nine weeks later the *Robert Dollar* tied up in San Piedro, California. We were to be there unloading for three days. I told the skipper I'd take the time off to visit my grandmother back in the hills. He just winked and asked if she had a girl friend for him.

"I arrived in San Gabriel that noon and checked into the small local hotel. Then I hired a horse and buggy from the livery stable and drove out to the Shellhamer estate. Just as Tetzlaff said, there was an old Bavarian castle, perched on the side of a hill. The stone wall surrounding it must have been 10-feet high.

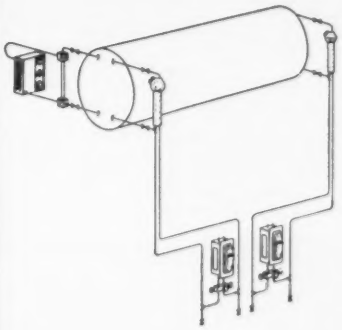
"As I hitched the nag to a tree near the wall I was greeted by a chorus of ferocious barking. Those brutes meant business. Walking along the wall, I came to a fancy wrought-iron gate. The dogs had followed me along inside and suddenly we came face to face, with only the gate between us. They were monsters, with saliva drooling from their bared fangs as they tried to get at me through those bars. But soon as I saw those two savages I had my answer for getting past them.

"Without wasting time I drove back to the hotel and started pumping the manager. He had grown up in town and knew all about the Shellhamers. Told me the old man lived with two ancient servants. The nephew spent every Monday at the estate. Rest of the time he was in town or in Los Angeles, gambling and raising hell. All deliveries were

HOW BOILER CODE CASE #1155 EXTENDS USE OF YARWAY REMOTE INDICATOR

Under A.S.M.E. Boiler Code Committee ruling in Case #1155, two independent remote level indicators of compensated manometric type may be used instead of one of two required gage glasses for boiler pressures 900 psi and above. When both indicators are in operation, the gage glass may be shut off but shall be maintained in serviceable condition.

Yarway Remote Liquid Level Indicators conform to this ruling and can be used for primary boiler water level indication in plants operating at 900 psi and above. Sketch below shows typical hook-up.



If you would like a reprint of this Boiler Code ruling, just ask for Case #1155 reprint.

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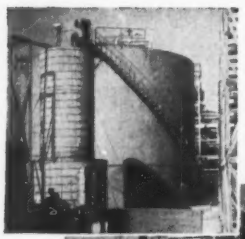
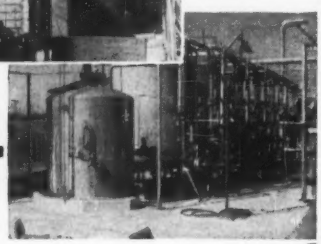
circle 287 on Reader Service card, p 123

WHO CHOSE H&T ?

For Boiler Feedwater Conditioning Equipment



400,000 lb. per hour fully automatic demineralizer plant with silica and CO_2 removal



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West Milton, N. Y.

The Cleveland Elec. Illuminating Co.
Ashtabula, Ohio

Chevrolet Div. Gen. Motors Corp.
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R. J. Reynolds Tobacco Co.
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circle 288 on Reader Service card, p 123

Marmaduke

Begins on page 154

made to the estate on Monday while he was there.

"That evening I called on a local character that the hotel manager had suggested. With that off my chest I was all set for getting over the wall.

"Everything worked so well next morning that ten minutes after I drove to the estate I was inside. Five minutes later I found Shellhamer sitting in a wheel chair in the shade of his patio.

"'How did you get in here and what the devil do you want?' he stuttered, getting pink around the gills. One of the old servants came hobbling out of the building, raving at me in broken English.

"'I'm the chief engineer of the steamship *Robert Dollar*,' I said quietly. 'My friend Arnold Tetzlaff, president of the Tetzlaff Machinery Co, asked me to call. He's been trying to see you about installing the most efficient refrigeration system that your money can buy. But your drunken nephew won't talk business with him because Tetzlaff won't give him graft.

"With that I spread out my sketches and started talking refrigeration before the old man had time to think. 'Look at this, Mr Shellhamer,' I said, pointing to the drawings and photos. 'Here's the equipment we propose. I understand your nephew is in the clutches of Los Angeles gamblers to the tune of $40,000—maybe more. And to pay them their money he's signed up with a junk dealer to install scrapped equipment. Right now they're painting and polishing everything to make it look new before delivery. But that scrap metal is sure to fail after a few months.

"The old man sat there staring at me with glassy eyes. But I continued, 'Your nephew's telling his buddies you won't last long anyway. He's buying junk so he can satisfy the gamblers and keep drinking and squandering all the money he can squeeze out of his shady deals.

"Then before the old boy could say anything, I gave him the Sunday punch. 'Listen to this, Mr Shellhamer,' I pleaded. 'Get in touch with your lawyer and banker. Take all rights to your money and business

Babbitt

Adjustable **SPROCKET RIM** *with Chain Guide*

Changes that Danger Zone to a SAFETY ZONE

The distance between the floor of your plant and your overhead valves is a DANGER ZONE when piled up boxes or even ladders are used to reach the valves.
Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. If your supplier does not carry them, contact us direct.

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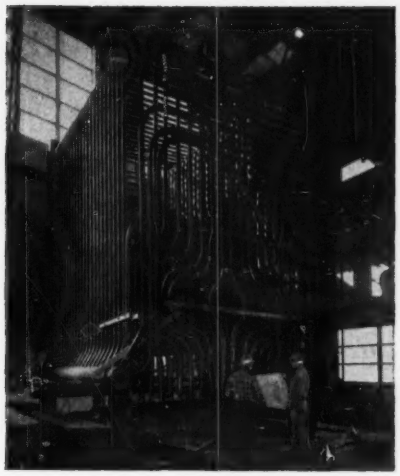

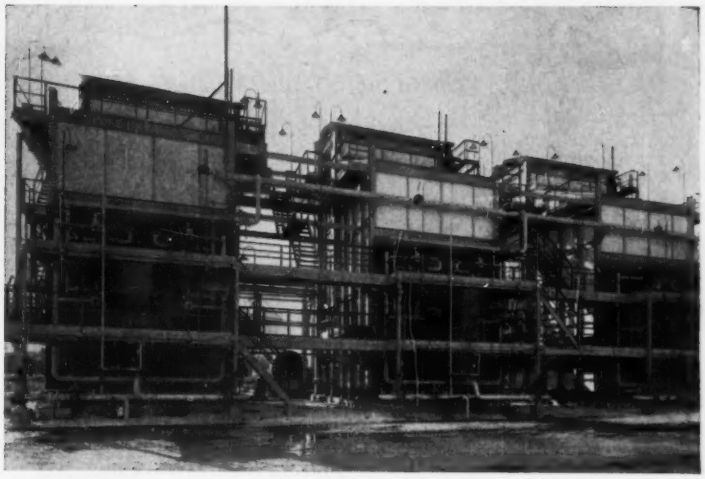

AT LEFT: Installing a 60,000 lbs/hr unit in a brewery

ABOVE: A battery of 125,000 lbs/hr units in a chemical plant

CUSTOM *Steam* GENERATORS by Vogt

Vogt engineering advances can save you money if you have a steam generating problem. Custom-built installations shown, are engineered to assure efficient, dependable steam generation for power, process and heating. Our engineering staff is available to give effective help in the solution of steam generating problems peculiar to a wide variety of operating conditions. Address Dept. 24A-BP.

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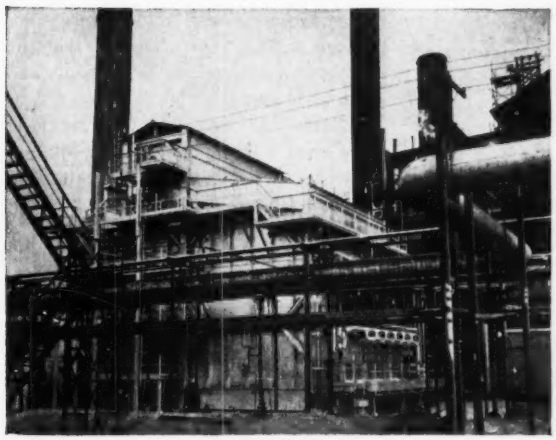
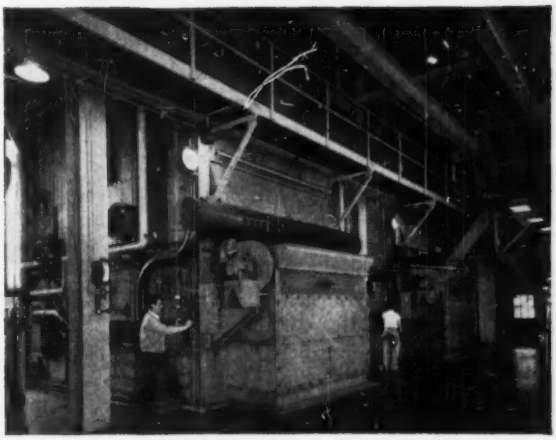
Vogt FOR BETTER BOILERS





This 400,000 lbs/hr unit is installed in a leading petroleum refinery

Three 40,000 lbs/hr units serve a medical center

For more facts circle 291 on Reader Service card, p 123

But A. O. Smith smokestacks —glass-protected inside and out—are virtually impervious to condensate attack

For free bulletin containing full facts on why A. O. Smith stacks are your best stack investment, write Dept. P-129.

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SMOKESTACK SALES • PROCESS EQUIPMENT DIVISION
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For more facts circle 292 on Reader Service card, p 123

LET BLACKMER SOLVE IT

Because of their unique design, Blackmer self-priming rotaries have been successful for years in overcoming high suction lifts even with thick, sticky substances or with volatile liquids, where cavitation can be serious. Whatever your pumping problem, let Blackmer solve it. Write for Bulletin One.

BLACKMER

"liquids materials handling"® equipment

BLACKMER PUMP COMPANY, GRAND RAPIDS 9, MICH.

See Yellow pages for your local sales representative

For more facts circle 293 on Reader Service card, p 123

Marmaduke

Begins on page 154

away from your nephew. Either cut him off or put him on a small allowance. Have your new plant managed by a board of directors. Or better yet, soon as you build the plant, sell it and the good will you've built up all these years. Then leave your money to some engineering school.'

"While he sat there staring at me in disbelief, I wound up my argument. 'Have your banker check up on Mr Tetzlaff's firm. You'll find him the squarest-shooting Dutchman, next to yourself, in California. And you'll find the equipment we have planned here will save you a good $10,000 over anything comparable you can install.'

"The old man listened, but kept trying to look over his shoulders, as if expecting someone or something any minute. Gradually he got interested in my plans, then asked me to sit down.

"A half-hour later I shoved the contract before him to sign. 'You know, Mr Whatever-your-name-is,' he said, 'you're the first human being to get past my dogs. My nephew got them to guard me against crooks and pests. I'll sign this contract because it makes sense. But before I sign, please tell me one thing. Where are my dogs? I haven't even heard them bark since you arrived.'

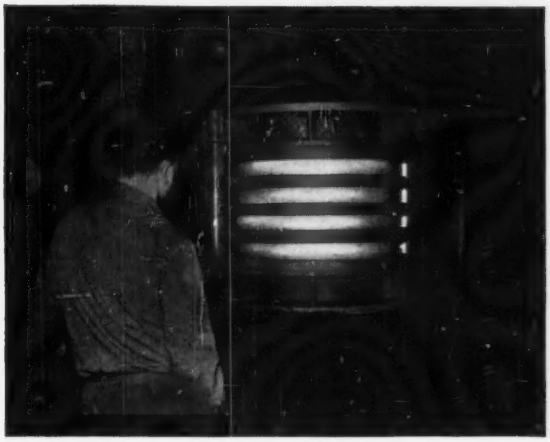
"'Very simple,' I answered. 'Just like machinery, you have to know what makes dogs tick. I visited Charley Zangara the dog breeder yesterday. He rented me a swell-looking bitch that's in heat. I put a ladder against your wall and lowered her over with a rope. Then I tied the rope to a tree on the outside and climbed over the wall.'

"The old man bust out laughing so hard I thought he'd have another stroke. After he wiped the tears from his face he signed the contract. 'From now on, *I* sign for everything,' he said. 'I'll get my banker to appoint a smart manager and put my nephew on allowance, as you suggest. And you come to see me any time you wish,' he continued, sticking out his hand. Then he added, poking me in the ribs, 'And you won't even have to bring company for my dogs.'"

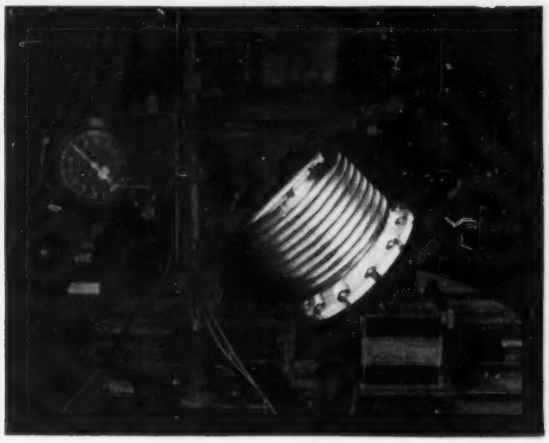
—STEVE ELONKA

continued

4 WAYS to get maximum reliability in expansion joints



1 Insist that the corrugated bellows be hydraulically formed. The reason is simple. Whenever bellows are formed by circumferential welding . . . whether by edge, seam or fillet welding . . . they will always be subject to premature failure because of stress concentrations at the welds.



2 Be sure the manufacturer maintains a continuous and comprehensive program of endurance testing. This is basic, because of the many variables that affect expansion joint life. Accurate determination of expansion joint life expectancy can only be determined by cycling to destruction.

3 Demand proof that the manufacturer can produce longitudinal welds in the corrugated bellows having the same strength, physical properties and thickness as the parent metal . . . without grinding. A weld that is hard to find is a ground weld. Variations in weld thickness set up points of stress concentration . . . opening the way for premature failure.

4 Check the ability of the manufacturer to supply a team of *competent* design and application specialists to work with your engineers. Check their specific experience in handling critical, complex applications in your field . . . complete to the record of successes or failures behind them, and details of how this experience will be brought to bear on your problem.

At Zallea, none of the many factors affecting expansion joint reliability are left to guesswork . . . including the four vital ones above.

This is reflected in these facts. Zallea material specifications are the most exacting in the industry. Zallea expansion joints are hydraulically formed. Zallea advanced welding techniques insure welds having the same thickness, strength and physical properties as the parent metal. Zallea has done more cyclic testing to destruction than all government agencies and industrial firms combined. Zallea has produced more expansion joints than any other manufacturer . . . offers more application engineering experience.

For all the facts, write for Catalog 56. Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Delaware.

Zallea for maximum reliability

ZALLEA BROTHERS, Wilmington 99, Delaware • World's largest manufacturer of expansion joints

For more facts circle 294 on Reader Service card, p 123

ENCO BURNERS

FOR OIL, GAS OR TAR

Steam or mechanical atomizing...1 to 1000 gallons per hour

Designed for operation with either gas, oil or both with natural or forced draft. They can be depended on for maximum combustion efficiency.

ENCO Interchangeable Oil-Burners can be changed instantly to operate by either steam or mechanical pressure atomizing over a wide capacity range.

ENCO Oil Atomizers are applied to various types of standard pulverized coal and gas-burner units cold starting or for full load operation when coal or gas is not available, or when oil is the more economical fuel.

Send for Bulletin OB-53 describing ENCO Gas and Oil Burners, also complete Pumping and Heating Units.

EC 809

THE ENGINEER COMPANY, 75 West Street, New York 6, N. Y.

For more facts circle 295 on Reader Service card, p 123

FOR CHRISTMAS

GIVE

MARMADUKE

SURFACEBLOW !

Not really the old gent himself, of course, but a collection of 21 of his famous stories, colorfully bound. Only $1.00, it will give much amusement, and engineering tips, too, to all engineers on your list.

USE THIS COUPON TO ORDER

POWER, 330 West 42nd St, New York 36, N. Y.

Please send me _____ copies of Marmaduke at $1.00 each*

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*Deduct 10% on orders of 10 or more

Marmaduke

Begins on page 154

Marmy's Mailbox

'Tis here you exchange blasts with the old boy

FIRST THINGS FIRST

Soon as POWER arrives—Marmy is the first story I look for. It's always interesting to see what the old consultant is up to.

J P RICHTER, *Kinston, N. C.*

FEMALE FAN

I think the Marmy stories are fascinating. Although I know nothing of the power field, I look forward to his story when POWER arrives, as do others in our office. More POWER to him.

MARION WONG, *San Francisco, Calif.*

BRINGS BACK MEMORIES

As a field engineer for Wright Chemical Corp I get a bang out of reading Marmy's adventures. They bring back my own experiences in ship engine rooms. It's always a pleasure to anticipate his next adventure.

C J CARROLL, *Baltimore, Md.*

OS&Y VALVES

Marmy's little drip in July, 1959 POWER is a good reason why outside screw and yoke valves should be used. Valve stem in that story would have shown the operator that the valve had been closed.

W F RYAN, *Salina, Kan.*

ONE-SQUIRT DIVRIKI

That story sure is a honey. Talk about slapstick comedy in the old 2-reelers! This one is about the funniest of all the Marmy stories.

F ARDOLINO, *Brooklyn, N. Y.*

PLEASED WITH BOOK

I'll treasure my book of Marmy stories. My son, a department head at a local firm here, also enjoys the stories. Marmy reminds me of a very dear old chief engineer I knew, who was rough and tough but had a heart big as life itself.

A R VAUGHN, *Indianapolis, Ind.*

continued

circle 297 on Reader Service card, p 123

AN "O" RING
for every purpose
EFFECTIVE SEALING

Ankorite "O" rings provide effective sealing through a range of pressures, temperatures and movements. When properly applied they exert low running friction on moving parts.

They offer many advantages:

1. Production cost is reduced by elimination of complicated assemblies.
2. Special assembly tools are not necessary.
3. Economical to use since only one "O" ring is required on piston or rod.
4. Long life, fluid-tight packing is assured with correct design and machining of grooves and mating parts.

Anchor has developed standard compounds to resist the actions of fluids such as air, gas, oil and chemicals over a wide temperature range. For more specialized applications, a wide variety of compounds is available. Data on sizes, etc. available on request.

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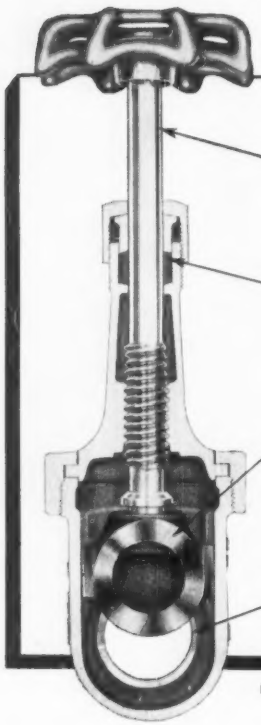
Outstanding Valve performance with

KENNEDIZED DISCS

an entirely new development in bronze gate valve construction that extends service life beyond comparison . . .



PROVEN BY USE!

KENALLOY STEM . . .

Exclusive KENNEDY alloy that prevents dezincification and corrosion and provides smooth, non-galling threads and bearing surfaces. In a rugged use test, this stem withstood a mechanical loading of 18 foot-pounds closing torque and after 25,000 cycles was like new!

PACKING . . .

New type packing made of molded graphite asbestos with a Buna "N" binder required no replacement during or after 25,000 cycles.

KENNEDIZED DISC . . .

In punishing use tests, the super mirror finish of the KENNEDIZED disc actually improved with wear! Disc showed no galling or other wear marks after 25,000 cycles at 150 lbs. saturated steam pressure. This remarkable wear resistance is combined with an extremely low coefficient of friction, smooth sliding properties, excellent anti-seizure characteristics and corrosion and galling resistance. Tests and in-use results prove these discs set a new and unmatched high standard in valve performance.

SEAT . . .

Due to the low coefficient of friction and smooth sliding properties, the action of the KENNEDIZED disc actually improved the finish on the seat. Here, again, no galling was found on the seat after 25,000 cycles.

For the complete KENNEDIZED DISC story, write for Bulletin 574.

Fig. 525KD
125-Pound S.W.P.
Bronze Gate Valve.

KENNEDIZED DISCS NOW AVAILABLE IN THESE KENNEDY VALVES . . .

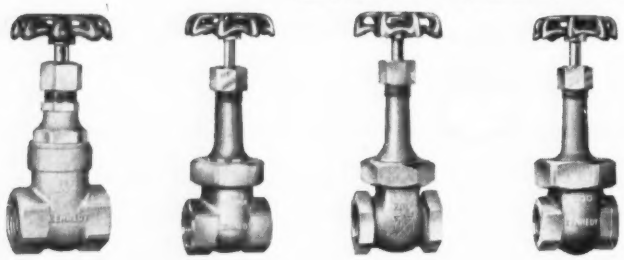


FIG. 427KD
125-Pound S.W.P. Bronze Gate Valve—Non-Rising Stem, Inside Screw, KENNEDIZED Wedge Disc.
WORKING PRESSURES: Saturated Steam, 125 lbs.; W.O.G., Non-Shock, 200 lbs.

Fig. 525KD
125-Pound S.W.P. Bronze Gate Valve—Union Bonnet, Rising Stem, Inside Screw; KENNEDIZED Wedge Disc.
WORKING PRESSURES: Saturated Steam, 125 lbs., W.O.G., Non-Shock, 200 lbs.

Fig. 78KD
200-Pound S.W.P. 550° F. Bronze Gate Valve—Union Bonnet: ¼"-2", Bolted Bonnet: 2½"-3", Rising Stem, Inside Screw; KENNEDIZED Wedge Disc.
WORKING PRESSURES: Steam at 550° F., 200 lbs.; W.O.G., Non-Shock, 400 lbs.

Fig. 518KD
300-Pound S.W.P. 550° F. Bronze Gate Valve—Union Bonnet: ¼"-2", Bolted Bonnet: 2½"-3", Rising Stem, Inside Screw; KENNEDIZED Wedge Disc.
WORKING PRESSURES: Steam at 550° F., 300 lbs., W.O.G., Non-Shock, 600 lbs.

KENNEDY VALVE MFG. CO.
ELMIRA, NEW YORK

• OFFICE AND WAREHOUSES IN PRINCIPAL CITIES

DUCTILE IRON VALVES • CAST IRON VALVES • BRONZE VALVES • INDICATOR POSTS • FIRE HYDRANTS

Marmaduke

Begins on page 154

STILL LAUGHING

We passed the April, '59 story, *Marmy's one-squirt divriki*, around the plant and we are still laughing. I have never heard of so much damage being done by one squirt of carbon tet in the right place. I've been saving all the Marmy yarns since they first came out in Jan, 1948, and putting them into a scrapbook. I had a lot of fun with the Marmy book I purchased some time ago and sent it out to friends. They couldn't thank me enough, and now they're all Marmy fans.

G AVANT, *Wilmington, N. C.*

TRAVELS WITH MARMY

Enjoyed my Marmy book while traveling around the country. We in the mechanical division of General Mills here think the old boy a crackerjack engineer.

G W SCHWARTZ, *Minneapolis, Minn.*

AN OLD FRAUD?

Your "1914 portrait," indeed, Mr Marmaduke. I'm betting you *still* look like that rakish guy with the devilish twinkle in your eyes.

F SMITH, *Chicago, Ill.*

ANOTHER GIRL FRIEND

As a female reader of POWER, I certainly enjoy Marmaduke Surfaceblow and his adventures. My uncle is an engineer and passes on his copies of POWER to me. I've also read the Marmaduke book. I realize not many women read POWER, so I thought you'd like to know Marmy has a few female friends who really think he's a lovable chap in spite of his burlyness. Keep writing those wonderful stories and I hope to see Marmy on TV some day soon.

BARBARA D LOPEZ

MARMY AUTHENTIC

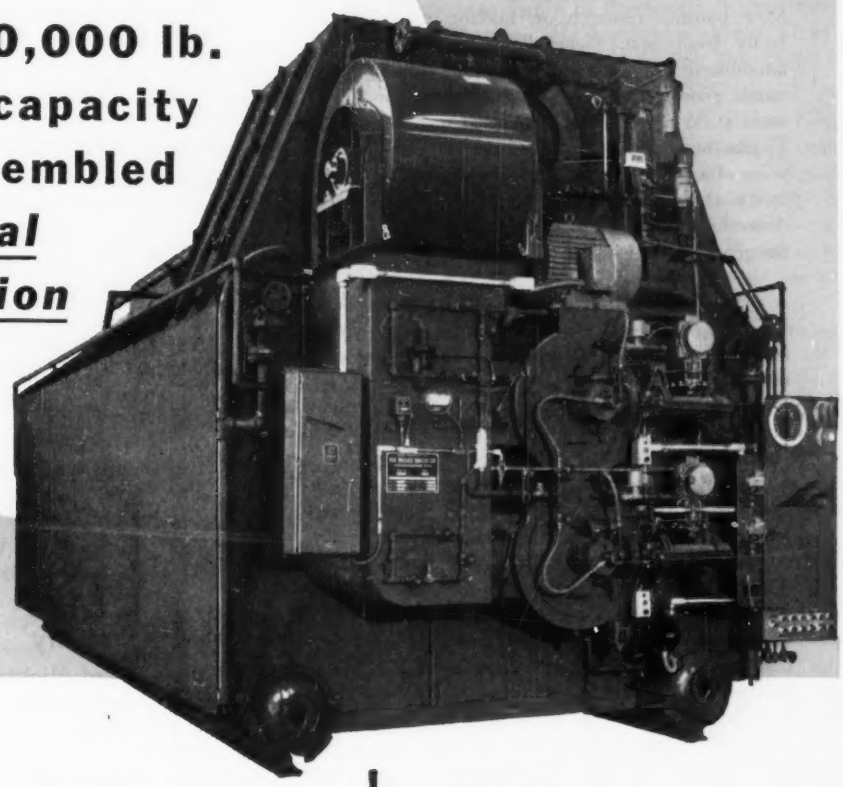
I find Marmy interesting. It just happens that I was in Santos, Brazil when Nov, 1958 POWER arrived with *Marmy's low resistance*. The story was about Santos and I did a double-take when I saw the illustration. It was certainly authentic of the coffee-loading operation. In my book POWER is the best all-around engineering magazine anywhere.

E PENDZIMA, *New Orleans, La.*

For more facts circle 298 on Reader Service card, p 123

...now from WICKES

a new 100,000 lb. per hour capacity shop-assembled *natural circulation* boiler



Wickes Type A units are of simple design, ruggedly constructed and adaptable to a variety of operating conditions and may be fired with oil, gas or combination of both.

All units are shipped completely shop-assembled including superheater, fuel burning equipment, safety and combustion controls, forced draft fan and drive, soot blowers and feedwater regulator.

Save on

- **First Cost**
- **Operating Expense**
- **Space**
- **Delivery Time**
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For more detailed information on Wickes Type-A steam boilers, write for our catalog 56-1. Bulletin 55-1 covers the complete line of Wickes Products and Facilities.

WICKES type A

WICKES

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For more facts circle 299 on Reader Service card, p 123

Powerscope . . . A selective look at

Making electrons move

Military needs and long-range commercial promise have boosted research on making electricity directly from heat. General Electric Company has announced a laboratory-model mangetohydrodynamic generator that produces 800 watts for 3 seconds at 31 volts. Air, ionized by heating to 5000 F, jets through a hollow quartz block held between poles of a powerful magnet. The quartz picks up the free electrons, pushed by the magnetic field, to send them through a closed circuit. Thermal efficiency of the generator runs about 50%.

A symposium sponsored by Whirlpool Corp in Washington, D.C., revealed progress made in thermoelectrics where thermocouples were used to produce heat and cold when energized electrically. Semiconductor materials recently compounded can now develop over 100-F difference between hot and cold junctions—in a few years researchers expect to develop materials for differences of 180 F. Wall panels can either heat or cool a space automatically. A 6-compartment food cabinet for military aircraft holds precooked foods at freezing; flicking a switch on any compartment reverses current flow to heat food to serving temperature while the other compartments remain frozen. A compact water distiller uses thermoelectric junctions to evaporate brackish water and condense the vapor. As generators, the newer semiconductors work at a thermal efficiency of about 7% for a 1000-F difference at the junctions.

Niagara Falls, N. Y. plant of Olin Mathieson Chemical Corp will have the largest silicon-rectifier-converter system in the U.S.A. In filling the $1-million order, General Electric Co will build a 27-mw system to supply 100,000 amp at 270-v dc. System uses 60-cycle ac as the source to supply dc to chlorine-caustic cells. It will be easier to run and maintain than the rotary equipment it replaces and also more efficient.

Crystal ball—modern version

***Powercasting*, a new service offered by Westinghouse Electric Corp, will help utilities to forecast their long-range equipment needs accurately. The program uses mathematical models that duplicate all or any part of a utility system. With a digital computer day-by-day operation can be simulated for 20 years or longer. The program takes into account all system variables: technical, financial and human. Operational gaming methods — a combination of system analogues, Monte Carlo techniques and human competition— provide solutions to problems that can't be adequately described by equations. The first study now under way for a large Eastern utility will analyze many expansion patterns and help choose the best one.**

Expanding research center

Westinghouse Electric Corporation is expanding its research center at Churchill Borough near Pittsburgh, Pa. by adding two new buildings on the 100-acre site. Ground will be broken in early 1960 with occupancy scheduled for 1961. Company's materials laboratories, new-products laboratories, manufacturing-planning and controls lab and the patent department will make up the new research-and-development center.

Designers of the Kharkov Turbine Works in the Ukrainian SSR have laid plans to build a 50-mw gas turbine, largest announced to date in the world. At low ambients this turbine will be able to develop an output of 60 mw. Unit will have only half the weight of a steam turbine.

Reaching to infinity

University of Michigan boasts having a new radio telescope that ranks first in resolving power—ability to "see" fine detail—though it is only fourth largest in world. Free electrons coming close to protons in gaseous nebulae accelerate and produce radio waves. The 85-ft saucer-shaped antenna: (1) penetrates cosmic dust clouds to "see" spiral form of the Milky Way (2) permits studying regions where stars come to life and die (3) picks up radio waves from space that are a half-billion years old (4) tracks celestial objects for 12 hr at a time (5) aims at a sky region within an error of one part in 40,000.

W D Kendall, President of American Marc, Inc, predicts that 35- to 50-hp diesel engines may soon power the American family car, making it last six times longer than today. The engine now under development will first be made for marine work, later for cars. The engine will be able to power cars up to 3700 lb at speeds up to 75 miles per hr.

ASME and ASA announce publication of *Trial American Standard Class 5 Interference-Fit Threads, B1.12* for machine designers. These make threads on "bolt" parts slightly larger than threads on "nut" parts. When forced together these threads become the same size. The metal compresses and flows so parts will not shake loose even under severe vibra-

tion. These threads have been used for years in automobile engines, aircraft, boilers and other equipment where screws can't be locked into place or where they might shake loose. But many problems were met. The new Standards have tolerances designed to afford enough torque so members will not loosen in service and yet will not cause seizing, galling or torsional failure of parts.

U.S. Army Corps of Engineers had their dredge *Langfitt* in drydock at Todd Shipyards Corp in New Orleans, La., for annual overhaul. Condensation on the hull from high humidity made it impossible to paint. After two days' delay a wall of plastic 14-ft high was built around the 350-ft hull. Into this space two 55-ton air conditioners pumped 30,000 cu ft of dried air every minute. This stopped the sweating, allowed painting.

Tacoma, Wash., has issued calls for bids on a contract to complete its Mayfield Dam on the Cowlitz River—a gravity-arch concrete dam and a separate powerhouse. These were started several years ago and then halted by litigation that has since been settled. Separate bids will be called later for turbines, generators, switchgear, gates, substation and a powerline. Entire project must be completed by July 1, 1962. The plant will have three 40-mw generators with space for a fourth. Work on the 300-mw Mossyrock project upstream from Mayfield must be under way April 1, 1961.

National Electrical Manufacturers Association has rearranged its 33-yr-old organization to meet the new era of electric-industry expansion. The 65 industry-product Sections will be reorganized into eight semi-autonomous Divisions each guided by its own Board of Directors. These will be represented in NEMA's policy-making levels by elected Divisional vice-presidents. Divisions will be made up of Sections whose member companies produce: (1) consumer products (2) lighting equipment (3) industrial equipment (4) building equipment (5) insulating material (6) wire and cable (7) generation, transmission and distribution equipment (8) industrial electronics and communications equipment.

One man's opinion

Economist P A Rinfret of Lionel D Edie and Co, Inc told NEMA annual meeting that growth industries of the future are not necessarily the growth industries of the past. Present ten top growth industries are: electric utilities, consumer boats, foreign travel, missiles, electronics, office equipment, housing, aluminum, plastics and drugs. Economy will be more vulnerable to fluctuations than during past 13 years. He forecast a gain of about 3½% yearly in volume during the 60's.

J W Simpson, Vice President of Westinghouse Electric's atomic-power division, advises today's engineering undergraduates to avoid specialization and stay close to fundamentals of engineering science. Academic work behind a bachelor degree no longer qualifies the engineer for some of today's challenging engineering fields. Measure of success for an engineer is not limited to management positions—the respect he wins in his profession and among his colleagues is often more important.

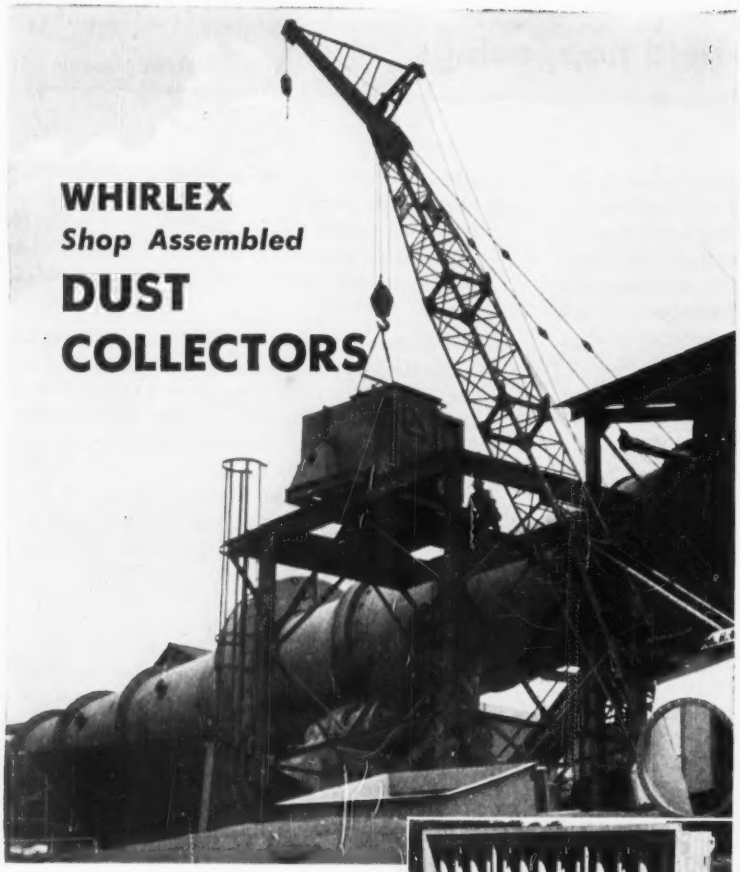
Air conditioning the man

Some day the fighting man may be individually air conditioned. A miniature conditioner placed inside a protective garment could keep him dry and comfortable in below-zero cold of the poles and searing heat of the tropics. Westinghouse scientists and engineers are working on a "package" under Navy contract to develop such a suit. The conditioner will be a thermoelectric device using small elements of a solid semiconductor material.

Alaska's glamor in song and story is now being matched in hydro-power proposals. One project for the Yukon River envisions a 5000-mw plant development costing $1 billion and impounding a reservoir larger than Lake Erie. A significant part of the surveying and mapping talent in the U.S.A. would be needed for several years just to plan the project.

Literature-searching service will be launched early in 1960 by the American Society for Metals. The project will supply subscribers with titles and information about documents on metallurgical science, engineering and fabrication and use of metal parts that appear in the world's literature. The service will use General Electric Co's first electronic-computer type machine designed for searching. It will search 100,000 indexed documents per hr and print out titles and sources of those pertinent to the subscriber's need. As many as 100 indexing terms can be provided for one document.

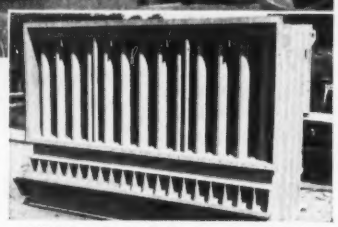
American Motors Corp and Sonotone Corp are researching an electric car using sintered-plate nickel-cadmium batteries expected to last the life of a car. This type battery can be charged faster than a conventional one.



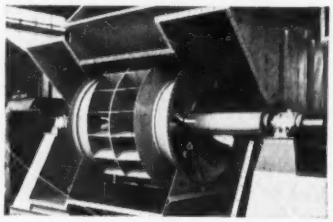
. . . Cut Erection Costs to a Minimum

This highly efficient Whirlex collector is completely shop assembled and need only be bolted in place at the erection site. Rigid shop inspection assures a "gas-tight" installation thus eliminating the opportunity of error at the job site.

A Whirlex Shop-Assembled Dust Collector may be the answer to your problem. Write for more complete information.



Whirlex Dust Collector completely fabricated and ready for shipment



Whirlex FD and ID fans are designed for heavy, rugged duty

Fly Ash Arrestor
CORPORATION
204 North 1st. Street • Birmingham, Ala.

Dust Collectors • Induced Draft Fans
Forced Draft Fans • Exhaust Fans
Self Supporting Stacks • Duct Work

FLY ASH WHIRLEX ARRESTOR

Reports from the field

Fuel cells power engineless tractor

Instantaneous conversion of chemical energy to dc electricity has come out of the lab and into the field, as 1008 fuel cells power an Allis-Chalmers experimental tractor. Propane-dominated mixture of fuel gases reacts chemically in an electrolyte within each cell, producing a total of 15-kw electricity.

The 1008 individual fuel cells are joined in 112 units of nine cells each. Units are arranged in four banks. Dc goes through bus bars to a controller, at driver's left, which varies speed or puts tractor into reverse by changing polarity of current flow to motor. Electricity is taken from any combination of banks, in series or parallel, depending on speed requirements.

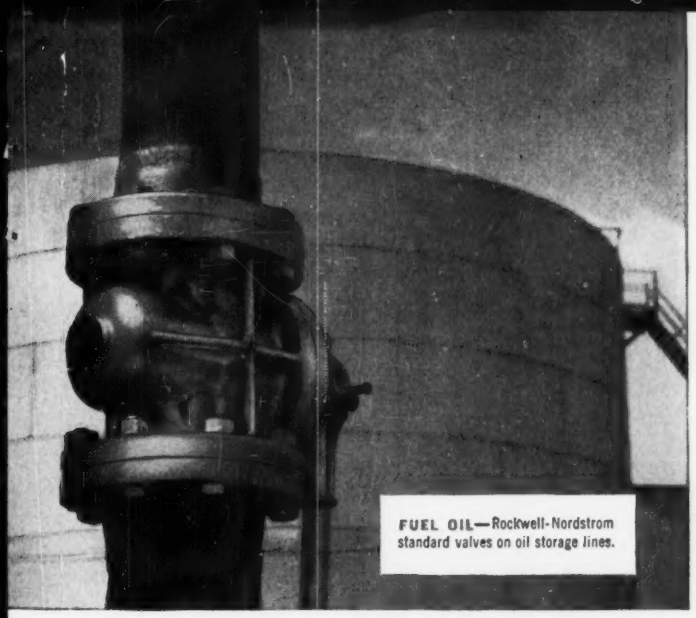
Research tractor is commercial size. It develops at least 3000 lb of drawbar pull, enough to pull a plow through dry, hard ground, say company engineers.

Basic fuel cell consists of electrodes and an electrolyte, like a conventional battery. The fuel cell, however, stores no energy—it instantaneously converts chemical energy to electrical, supplying power as long as its fuel supply lasts. Because no heat is involved, there theoretically need be no energy loss. Possible fuel-cell efficiencies of 90% are a tempting goal to power engineers now struggling with today's best efficiency levels—in the neighborhood of 40%.

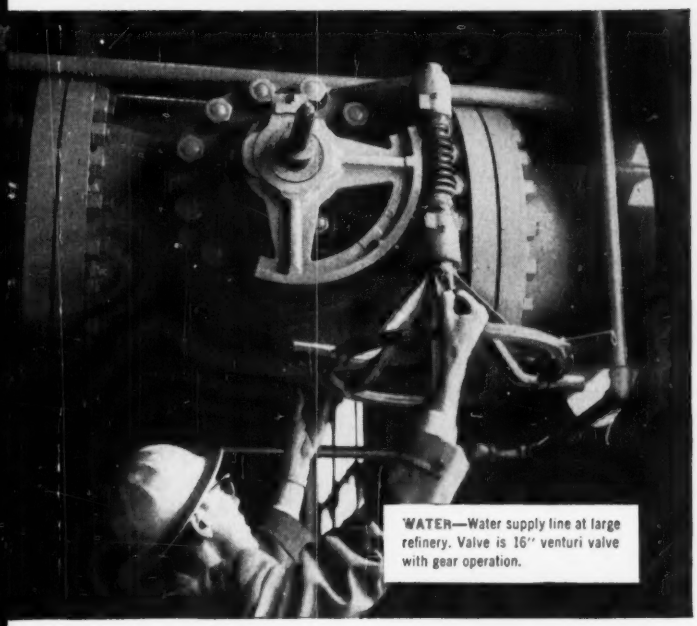
continued

For more facts circle 300 on Reader Service card, p 123

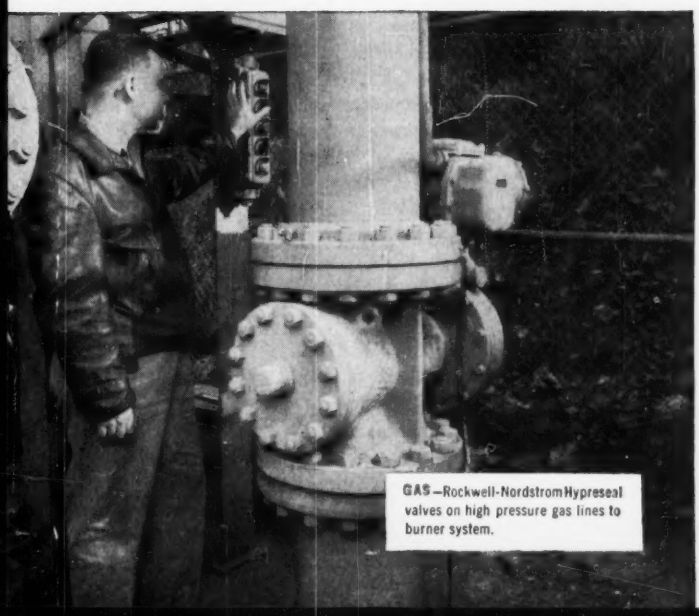
circle 301 on Reader Service card, p 123 ➤



FUEL OIL—Rockwell-Nordstrom standard valves on oil storage lines.



WATER—Water supply line at large refinery. Valve is 16" venturi valve with gear operation.



GAS—Rockwell-Nordstrom Hypreseal valves on high pressure gas lines to burner system.

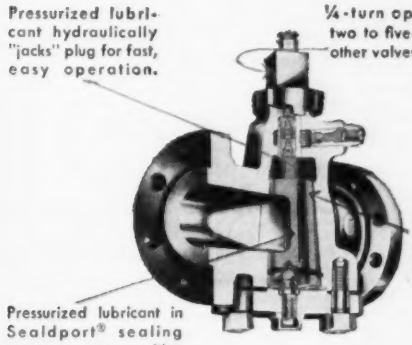
WHAT DOES LUBRICANT DO IN A ROCKWELL-NORDSTROM PLUG VALVE?

Pascal's Law* explains how Rockwell-Nordstrom lubricated plug valves can assure more dependable operation and tighter shut-off than non-lubricated valves. Too often, the lubricant is thought of as just a means of easing operation. Actually, the lubricant, under pressure, creates a closed hydraulic system that can minutely jack the *tapered* plug from its seat for instant operation. Also, pressurized lubricant forms positive pressure seals at each plug port to assure positive shut-off on any fluid. Finally, lubrication prevents wear and assures the economy, long life and dependability that can only be expected from a lubricated mechanism.

Advantages for Power Engineers:

For the main ingredients of power . . . gas or liquid fuel and water . . . Rockwell-Nordstrom valves will give you better flow control at far lower cost. Here's why they shut-off positively on *any* line material : . . you can throttle or shut-off with one valve . . . there's no up stream or down stream side for positive shut-off . . . they're more compact than other valves and can be installed in any position . . . they open or close with just a quarter-turn and lubricant keeps them ready for instant operation . . . *and* Rockwell-Nordstrom valves cost about the same, often less, than other valves. They are available in a complete range of sizes from ½" to 36", with a variety of power operators and operating accessories.

It costs nothing to get the facts. Write for full details or ask for a Rockwell Field Engineer to call: Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee: Peacock Brothers, Limited.*


Pressurized lubricant hydraulically "jacks" plug for fast, easy operation.
¼-turn operation. Closes two to five times faster than other valves.
Lubricant reduces turning torque and stops metal-to-metal wearing friction.
Pressurized lubricant in Sealdport® sealing grooves assures positive shut-off on every service.

*Pressure applied to a confined fluid is transmitted uniformly to all areas of the confining fluid.

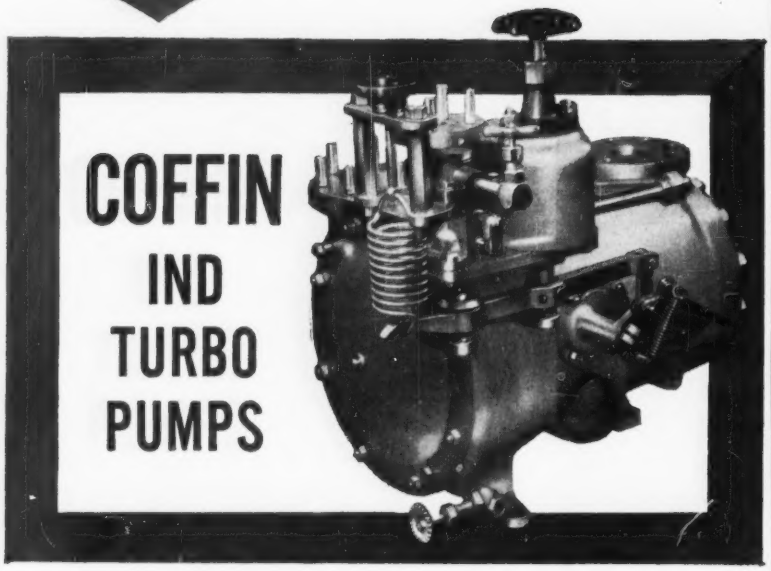
Lubrication makes the difference

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

Complete Pump, Turbine and Controls



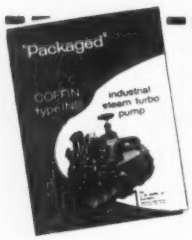
PACKAGED — integral design of the IND Pump results in a compact, highly efficient unit which mounts impeller and turbine wheel on a short, rigid shaft. The unit is equipped with complete controls for constant or differential pressure regulation.

APPLICATIONS — compact and highly efficient, the Coffin type IND Steam Turbo Pump is designed for General Boiler Feed or any other pumping service where medium volume and high pressure is required.

SPECIFICATIONS-

Capacities	to 180 GPM —	Height 32"
Discharge Pressures	to 350 PSIG —	Width 25"
Liquid Temperatures	to 300°F —	Length 32"

For special installations these ratings may be exceeded.



Coffin Turbo Pump Co.
326 South Dean Street, Englewood, N. J.
Gentlemen: Please send me illustrated booklet further describing the Type "IND" Pump.

Name _____
Position _____
Company _____
Street _____
City _____ Zone ____ State _____

fmc

COFFIN TURBO PUMP CO.
FOOD MACHINERY AND CHEMICAL CORPORATION
326 South Dean Street • Englewood, New Jersey
Agents in all Principal Cities • Cable Address: COFCO

Reports from the field

Begins on page 168

Lawson Stewart promoted to associate editor

With this issue, Lawson Stewart joins the ranks of associate editors on POWER's masthead. When he donned the editorial mantle in April '58, Lawson had a fine background of power-field experience. As assistant editor, he quickly grasped POWER's objectives and ideals, added new areas to his technical competence.

His major contributions to the October *Plant Design Issue* show growth in the journalistic and creative aspects of our work: this is a richly merited promotion.

Training course in NDT conducted by Magnaflux Corp

Intensive training course in nondestructive testing is conducted regularly at the Chicago, Ill. plant of Magnaflux Corp. The 5-day course covers basics, theory and practice. Lab inspection, class discussion and lectures with visual aids enliven the course for supervisors, inspectors, operators.

Since 1956, 364 men have completed the course. Studies include fundamentals and methods of fabrication used in metalworking, origin of defects in materials and parts, theory of magnetic-particle and fluorescent-penetrant inspection, testing techniques and interpretation.

Growing problem of air pollution gets attention

Eleventh annual Cleaner Air Week sponsored by the Air Pollution Control Association was observed in Oc-

SOLID! Section of Roebel bar for 22,000 Volt, 76,000 KVA turbogenerator stator.

The outstanding insulation for high voltage coils

NECCOBOND...solid insulation bonded to the copper provides longer life, greater strength and stability

In NECCOBOND, National has developed a complete insulation system, using mica, glass and a special impregnant. Its particular advantages for high voltage coils are:

- Exceptional thermal stability.
- Optimum mechanical and electrical properties.
- High heat conductivity.

NECCOBOND is based on time-proven insulating materials – mica and glass. These are welded by a special impregnant into a tenaciously bonded, resilient, voidless insulation wall. A unique method of fabrication assures homogeneous insulation.

When replacing high voltage coils, investigate the long term savings with NECCOBOND. You'll find our advice impartial—we offer all types of insulation.

For more information, call National's Columbus Plant . . . HUdson 8-1151. Or call your nearby National field engineer.

McGRAW EDISON

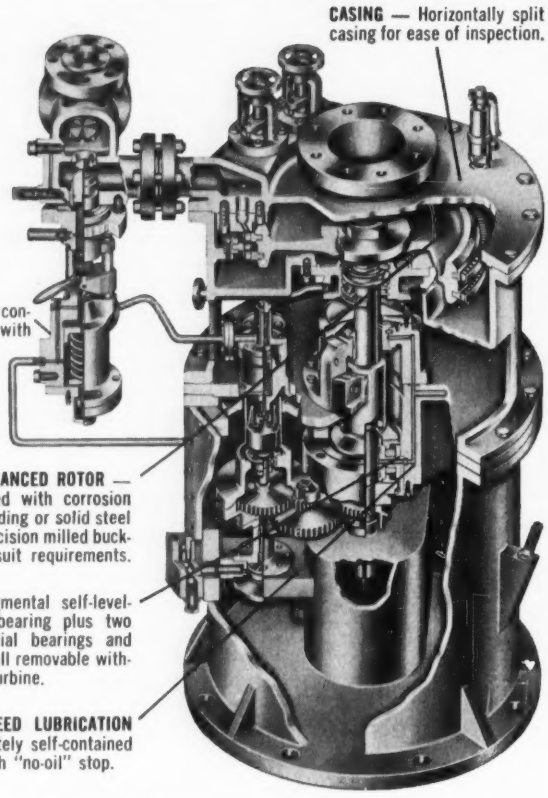
National Electric Coil

DIVISION OF McGRAW-EDISON COMPANY
COLUMBUS 16, OHIO

ELECTRICAL ENGINEERS • MANUFACTURERS OF ELECTRICAL COILS, INSULATION, LIFTING MAGNETS
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

NEW Whiton VERTICAL TURBINE

Type BHBSV for Vertical Pump Drives



CASING — Horizontally split casing for ease of inspection.

SPEED CONTROL — Oil constant speed governor with overspeed stop.

DYNAMICALLY BALANCED ROTOR — Either steel forged with corrosion resistant steel blading or solid steel one piece with precision milled buckets available to suit requirements.

BEARINGS — Segmental self-leveling type thrust bearing plus two babbitt lined radial bearings and shaft packing — all removable without dismantling turbine.

FORCED FEED LUBRICATION — Completely self-contained system with "no-oil" stop.

The Whiton Vertical Turbine is extremely versatile, compact and dependable . . . ideal for vertical pump drives and other similar applications. The vertical design requires minimum installation space and allows great freedom of location. Simplicity of design and construction results in ease of operation and servicing.

With this vertical turbine added to the line, Whiton's vertical and horizontal steam turbines offer a broad range of power supply applications. Complete data on the new vertical turbine and others available on request.

MAXIMUM OPERATING SPECIFICATIONS	
POWER	to 1000 HP
SPEED	to 8500 RPM
STEAM PRESSURE	to 1250 PSIG
STEAM TEMPERATURE	to 1050° FTT

Whiton SINCE 1856

THE WHITON MACHINE COMPANY
NEW LONDON, CONNECTICUT

Reports from the field

Begins on page 168

tober by millions of Americans concerned with problems of air pollution. Program this year, as in the past, had a twofold purpose: to broaden public understanding of the entire problem of air pollution and focus community attention on service rendered by public officials responsible for air-pollution control.

Celebration of Cleaner Air Week varied from city to city. Overall pattern outlined by a national committee of the APCA included speeches by air-pollution experts, radio and TV presentations and demonstrations of air-pollution-control equipment. Opinions and information were exchanged between various groups involved in air-pollution problems.

International meeting studies gas-lubricated bearings

Principles behind the design of bearings, lubricated by air or other gas instead of oil, were discussed at length by over 500 engineers and scientists at a 3-day meeting in Washington, D.C., October 26-28th. Attracted by the inherent advantages of gas lubricants—ability to operate at temperature extremes, noncontaminating, low friction, simplicity and quietness—both the military and private industry took a hard look at the state of the art while surmising where this growing technology might find a spot in their individual fields of interest.

The symposium, sponsored by the Office of Naval Research and conducted by the Franklin Institute, brought to light gas lubricants operating at speeds ranging from 165,000 rpm for high-speed turbocompressor units to between 100,000 and 500,000 rpm for some shaft-rotor systems now under development. At this meeting the British reported their successes in operating gas-lubricated bearings in connection with their gas-cooled nuclear reactors.

With gas-lubricated bearings now seeing service in precision grinders, instruments and some gas turbines, industry is currently busy evaluating

For more facts circle 304 on Reader Service card, p 123

New RIDGID® No. 141

Geared Threader for 2½", 3", 3½", 4" Pipe and Conduit

One Set of Dies!

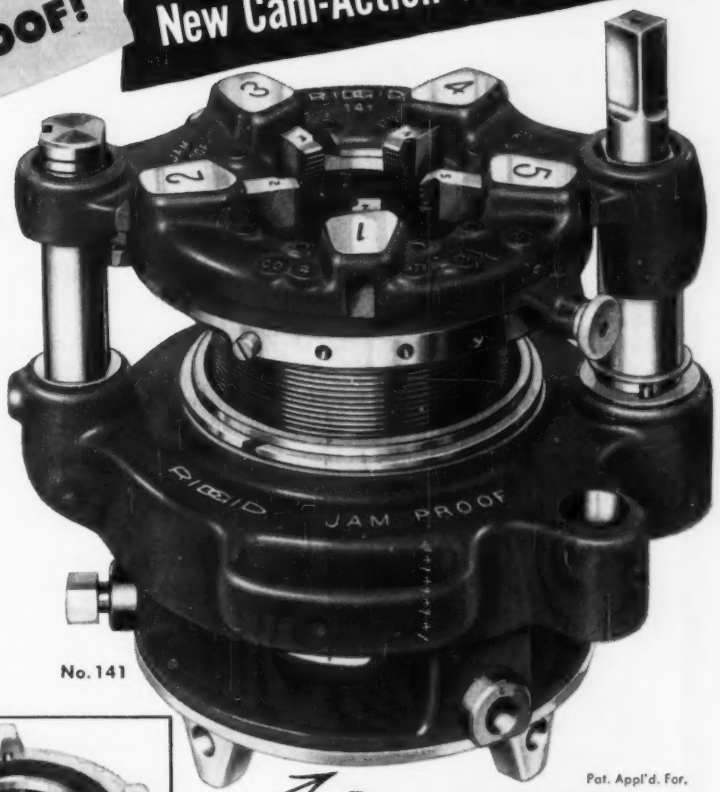
JAM-PROOF!

New Cam-Action Workholder!

Save Time . . . Cut Costs on all large threading jobs

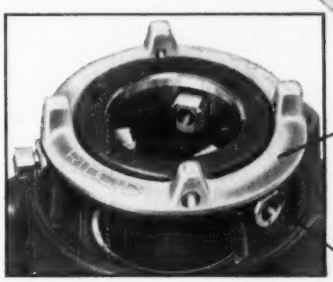
1. Only 1 Set of High Speed Dies threads 2½", 3", 3½" and 4" pipe and conduit. No extra die sets to change or lose! Die size change plate sets quickly and locks at desired size. Easy adjustment for tapered, straight, over or under size threads.

2. Jam-Proof for safe power or hand threading. Drive pinion kicks out automatically. Die head **Can't Jam** causing costly repairs and delay.



No. 141

3. New Fast-Action, Cam-Type Workholder sets to size by quick turn of collar. Set screw holds work centered for perfect threads every time.



Pat. Appl'd. For.

No. 161

For 4", 4½", 5" and 6" Pipe and Conduit, Buy the New RIDGID No. 161 Geared Threader!

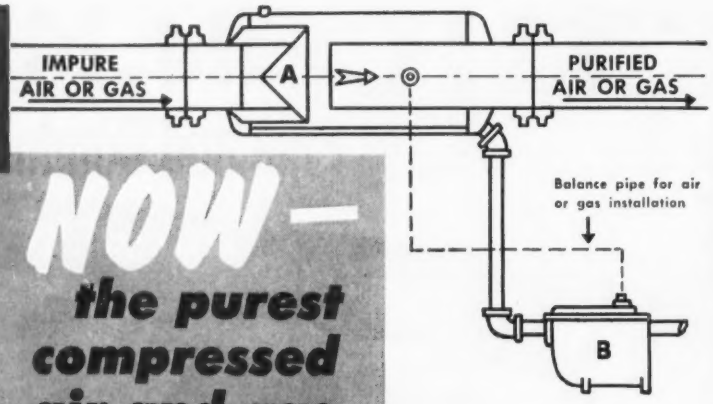
- Only 1 Set of High Speed Dies
- Jam-Proof
- New Fast-Action, Cam-Type Workholder

See and buy these work-saving RIDGID Threaders at your Supply House!

RIDGID

The Ridge Tool Company, Elyria, Ohio, U.S.A.

For more facts circle 305 on Reader Service card, p 123

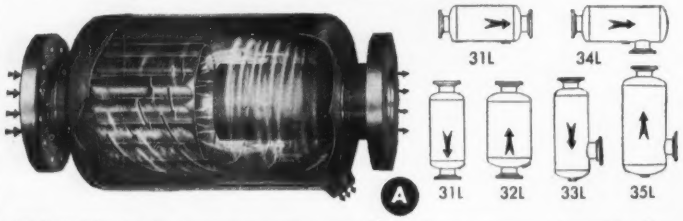


NOW— the purest compressed air and gas is yours with this W-A equipment

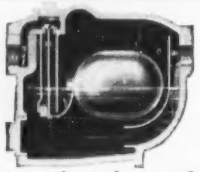
GUARANTEED TO REMOVE 99% OR MORE OF ENTRAINED MOISTURE AND SOLIDS

Where pipe lines carry compressed air and gas, liquids and solids are generally entrained in the gas stream. Wright-Austin 30L Series Separators can be used to remove foreign matter on a wide range of applications. For operating pressures to 5000PSIG. Line sizes to 24". Here are some typical applications:

REMOVE
—oil and water from compressed air supply lines
—oil and water on compressed air service at outlet of inter-cooler and after-cooler equipment.
—oil, moisture and tar between stages in coke oven gas compressors
—oil and water from CO_2 gas lines
—oil and water from hydro-carbon lines
—entrainment from vapor lines following evaporation



This Wright-Austin separator employs centrifugal force to remove impurities from steam, air or gas flow. The pressure drop is extremely low. Type 31N, as well as other models shown, is light weight, compact and sturdily constructed according to ASME code.



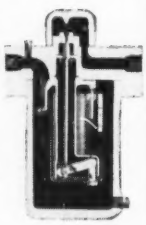
23-AC TRAP (0-125 PSIG)

Separated condensate flows to trap. Drainage is automatic. Particularly adapted where cold, gummy, emulsified cylinder lubricants make ordinary traps inoperative.

B

101-AC TRAP (0-600 PSIG)

Cast steel body, cover and bonnet. Designed for draining condensate where high pressures are involved. Internal mechanism all attached to cover for easy service.



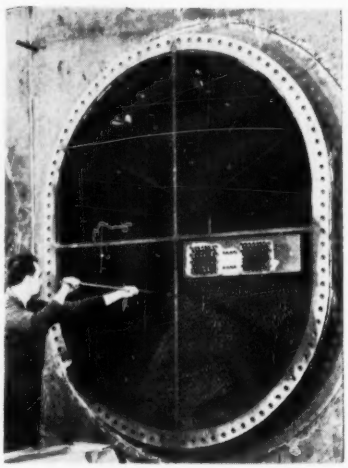
WP 1894 **WRIGHT-AUSTIN COMPANY**
3245 WIGHT STREET • DETROIT 7, MICH.

WRITE FOR NEW CIRCULAR 809-A

Reports from the field

Begins on page 168

just where the low load-carrying ability of the gas lube can be tolerated in light of the host of advantages which look so appealing at this early stage of development. Some researchers are even hopeful that gas may eventually be a practical answer in the current search for a fire-resistant steam-turbine lubricant.



Steam condenser uses 38 miles of brass tube

Largest condenser ever produced by Industrial Div of American-Standard contains 127,000 lb of tube. It was built for a central power station at Magna, Utah. Unit incorporates 38 miles of Admiralty-brass tubes supplied by Chase Brass & Copper. The 2-pass condenser has 58,000 sq ft of cooling surface to handle 415,000 lb used steam every hour.

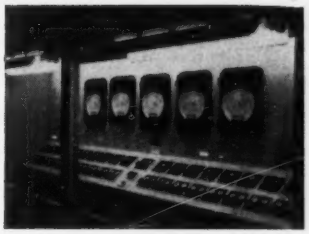
Large titanium-clad vessel proved successful

World's first titanium-clad pressure vessel of commercial size has proved a complete success according to S C Hamilton of the Chicago Bridge & Iron Company, vessel's builder. Vacuum cladding and special welding made it possible for the vessel to withstand months of strenuous service.

Designed for a working pressure

(Advertisement)

HAGAN NEWSLETTER
Behind the Panel



ANOTHER STEEL INDUSTRY FIRST FOR HAGAN

A large eastern mill has ordered what is believed to be the industry's first solid state combustion control system. Hagan PowrMag (magnetic amplifier) systems will be installed on a two-zone slab heating furnace, and will include zone temperature, zone fuel-air ratio, furnace pressure, recuperator temperature balance, and air pressure controls. Recording instruments (Hagan PowrLog) and panels will also be Hagan. Using PowrLog electronic recorders and PowrMag controllers, the system for each zone provides parallel operation of the combustion air damper and fuel oil control valve from the zone temperature controller. Fuel and air are measured and a fuel-air ratio correction is applied to the combustion air damper. The combustion air flow measurement is automatically compensated for temperature variations. Gas firing is contemplated for the future. (Item L-1)

GAS CONTRACT PENALTIES AVOIDED WITH RING BALANCE METERING

The increasing use of gas in the steel industry has brought about the necessity for central gas dispatching stations. By accurate control of gas usage, large users can avoid the penalties incurred when gas contracts are exceeded, and at the same time, make maximum use of available coke oven gas. Hagan Ring Balance meters have been chosen for this critical application by a large mid-western steel mill for a number of reasons, the most important being the inherent accuracy of the Ring Balance Principle. This basic accuracy is reinforced by the ability of the Ring Balance to compensate precisely for fluctuations in pressure and temperature, and the ease with which it can be calibrated. Add rugged construction, accurate electrical remote transmission and the ease with which range can be changed on a 7 to 1 basis, and the Ring Balance becomes the meter of choice for such applications. (Item L-2)

THESE SYSTEMS HAD TO BE EASY TO INSTALL

Easy to install—easy to calibrate—are commonly used phrases in the control business. But one Central American plant is willing to testify that this is strictly true—as far as Hagan systems are concerned. Combustion control, drum level control, meters and control panels were purchased from Hagan for a new 110,000 lb/hr boiler for a Central American steam electric station. Using Hagan instruction books and drawings, the entire system was installed, calibrated and put on the line without a single hitch, and a Hagan engineer has never been at the plant. All the systems have been functioning "beyond expectations" and maintenance has been minimum. (Item L-3)

HOW TO MEASURE A SMELL

To further decrease the risks of handling natural gas, an odorant is frequently added when the gas is transferred from underground storage areas back into the distribution system. The amount of odorant added is extremely critical, since too much makes the smell extremely objectionable, while too little makes the detection of gas leaks difficult. For this service, a pressure compensated Ring Balance meter, together with a Hagan ratio relay, controls a proportioning chemical feed pump. Installations of this accurate team are in service at a major gas supplier in the mid-west. Odorization of the gas is extremely accurate, and the installations have more than met the stringent specifications. (Item L-4)

HAGAN CONTROLS DO "SUBMARINE" SERVICE ON SURFACE VESSEL

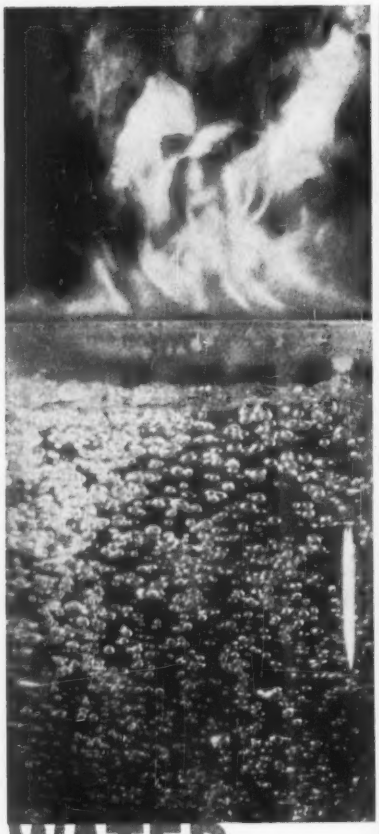
One of our largest surface ships is equipped with Hagan controls, including combustion, feed water and boiler feed pump systems. On a recent cruise, a defective main condenser valve allowed a main machinery space containing the Hagan combustion and feed pump controls to be flooded. The control systems were under water for a total of 36 hours. Crew members cleaned up the equipment, and when the carrier docked, Hagan service representatives were requested to check out the control systems. The controls were found to be in first class condition, needing only two minor needle valve adjustments. Hagan marine systems are not only extremely accurate, providing the most economical operation, but they are built to "take it." (Item L-5)

HAGAN CHEMICALS & CONTROLS, INC.

Hagan Building, Room 710, Pittsburgh 30, Pennsylvania
In Canada: Hagan Corporation (Canada) Limited, Toronto
European Division: Via Flumendosa No. 13, Milano, Italy
If you would like more information on any of the above items, check the appropriate box below.

☐ Item L-1 ☐ Item L-2 ☐ Item L-3 ☐ Item L-4 ☐ Item L-5

For more facts circle 307 on Reader Service card, p 123



WATER
FOR BOILERS
NEEDS
DEOXY-SOL

- to remove O_2
- reduce oxides
- raise pH

Fairmount DEOXY-SOL, a solution of hydrazine, is a high efficiency oxygen scavenger designed especially for high pressure boiler water treatment.

DEOXY-SOL removes oxygen, reduces oxides and raises pH of the condensate all at the same time . . . yet adds no solids.

Stocks in Newark, N. J., Chicago, Ill., Los Angeles, Calif. Investigate its advantages for your system. Write for Bulletin BW.

Fairmount
CHEMICAL CO., INC.
136 Liberty St., New York 6, N. Y.

circle 308 on Reader Service card, p 123

of 150 psi at 500 F, vessel measures approximately 4x12 ft and was fabricated from plates of ½-in. mild steel clad with 5/64- and 7/64-in. grade A-40 titanium. Hemispherical heads, top and bottom, were welded from pressed segments. Fittings and flanges were titanium-lined.

Success of this vessel opens the door for use of corrosion-resistant titanium-clad vessels throughout the chemical, petrochemical and other processing industries.

Belgium's first atomic plant begins operation next fall

A 11,500-kw plant is scheduled for operation in Belgium in September, 1960. The country's first atomic power plant, it will house a U.S.-manufactured power reactor built by Westinghouse Corp.

When reactor is complete, it will consist of 32 fuel elements, above, each with a total of 110 tubes holding pellets of uranium-oxide reactor fuel. Remaining eight elements will act as spares.

Westinghouse designed and developed the reactor portion for the Centre d'Etude de l'Energie Nuclaire, a nonprofit organization formed by the Belgian government, university scientific centers and Belgian industry.

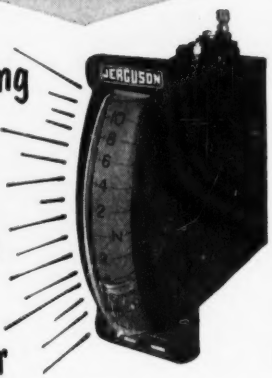
continued

Here's Jerguson's

New!
RED FLASHER
TRUSCALE

Remote Reading
Liquid Level Gage

Flashing
Red
Scale
Warns
of
Danger



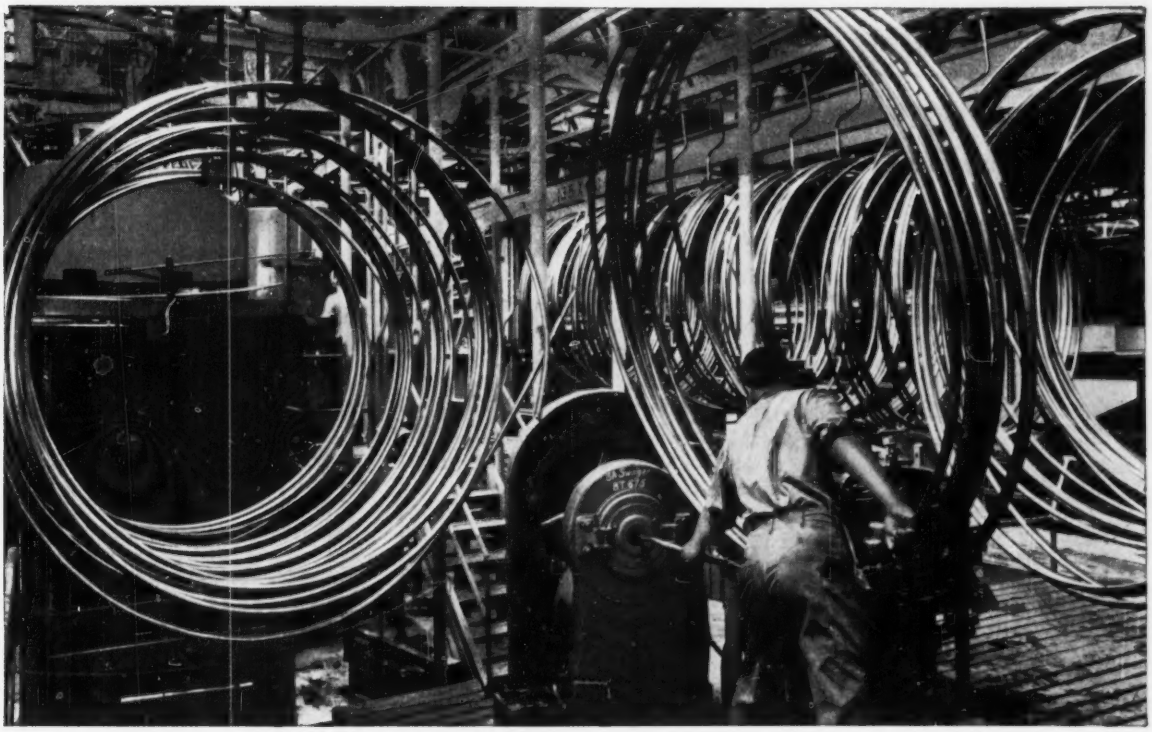
Jerguson Truscales are now available with a unique new safety feature. Illuminated scale starts flashing red if boiler water level gets too high or too low. This positive warning flashes continuously until the dangerous condition is corrected.

Truscales offer the greatest possible protection for expensive equipment. They give instant remote reading of liquid level of boilers, tanks, etc., with the amazing accuracy of ½ of 1% of scale reading. Convex face, with scale markings directly on it, gives 180° visibility. It's easy to take readings from any point from which the face can be seen.

Protect valuable equipment with Jerguson Truscale Remote Reading Gages. Send for new 8-page bulletin which gives complete details.

JERGUSON
Gages and Valves for the Observation of Liquids and Levels
JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities
Bailey Meters & Controls, Ltd., London, Eng.
Controle Bailey, Paris, France

See Booths 1211-1213, Chemical Show
circle 309 on Reader Service card, p 123



things you should know about

WOLVERINE TUBE

You know what they say—about change being the father of progress.

Well, that's the way it is at Wolverine Tube and we'd like to tell you about some of the new things going on at Wolverine.

For example, Wolverine recently completed a multi-million dollar modernization program at its Detroit, Michigan plant. New machinery and new tube-making techniques have made this plant one of the most modern in North America. Wolverine also operates large, modern plants in Decatur, Alabama and London, Canada.

There are new things afoot metalwise at Wolverine, too. In addition to copper and aluminum, Wolverine Tube now works in such metals as Columbium, Molybdenum, Tantalum, Titanium, Vanadium and Zirconium, etc. It's the result of an extensive research program started many years ago, and it gives Wolverine customers a big edge when they require an experienced tubing and fabrication source for these "metals of tomorrow."

Also, to insure top-flight sales service, Wolverine has expanded its nation-wide sales staff to include a number of highly trained Technical Sales Representatives. These men are specialists in all phases of tubing selection and application, particularly in the field of heat transfer. Their services are available at all times . . . you have only to ask.

So . . . if your company is looking for the finest of tubing and the finest of service, you'll find both at Wolverine Tube where improvement is a continuing program.

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION
In Canada:
CALUMET & HECLA OF CANADA LIMITED
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WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17268 Southfield Road
Allen Park, Michigan
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

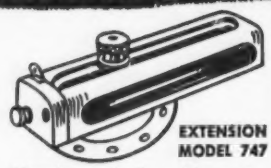
PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
SALES OFFICES IN PRINCIPAL CITIES

For more facts circle 310 on Reader Service card, p 123

"ON-THE SPOT" EFFICIENCY

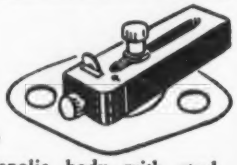
SPEARHEAD GASKET CUTTERS

HAND • TOOLS



EXTENSION MODEL 747

Aluminum body with steel blades and inch and metric scales. Cuts precision round gaskets any size



HANDY MODEL 750

Phenolic body with steel blades and inch and metric scales . . . cuts round gaskets ¼" to 6", odd shapes and straight pieces any size

ZIMMERMAN PACKING

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NEW YORK OFFICE
120 LIBERTY ST.
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CHICAGO OFFICE
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CHICAGO 46, ILL.

circle 311 on Reader Service card, p 123

More clean water at a lower cost with

S.P. KINNEY AUTOMATIC SELF-CLEANING

STRAINERS

. . . for efficient removal and disposal of suspended particles from raw or process water and other liquids

- Over 1000 installations
- 2" to 48" pipeline sizes
- Installation on pressure or suction side of pump

Write today for Bulletin 500-1P

S.P. KINNEY ENGINEERS, Inc.
CARNEGIE, PENNSYLVANIA

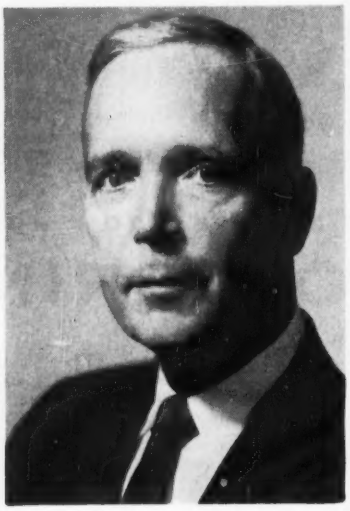
circle 312 on Reader Service card, p 123

Reports from the field

Begins on page 168

Packaged heat pump air conditions church

Congregational Christian Church of Fairfax County, Va. is one of at least seven other churches in the Virginia Electric and Power Company's territory to condition air by the heat-pump method. Carrier Corporation installed ten 5-ton heat pumps. Use of 2-piece units with compressors located outdoors gained 415 sq ft of usable area for the church.

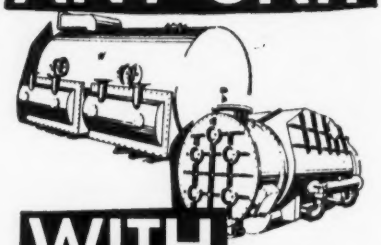


Industrialist honored by engineering societies

Gwilym A Price, chairman of the board of Westinghouse Electric Corporation, received engineering societies' top prize for his industrial leadership in the development of atomic power. Highest honor that engineers can bestow, the John Fritz Medal, was awarded to the Westinghouse executive at the ASME annual meeting at Atlantic City late last month.

At the end of World War II, recognizing the possibilities of the atom and military significance of nuclear propulsion, Mr Price formed an atomic-power organization within his company which developed the historic atom plant for the *U.S.S. Nautilus*. Men he brought together have designed nuclear-propulsion plants

ANY UNIT



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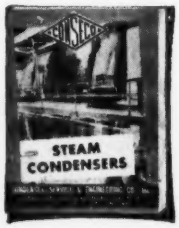
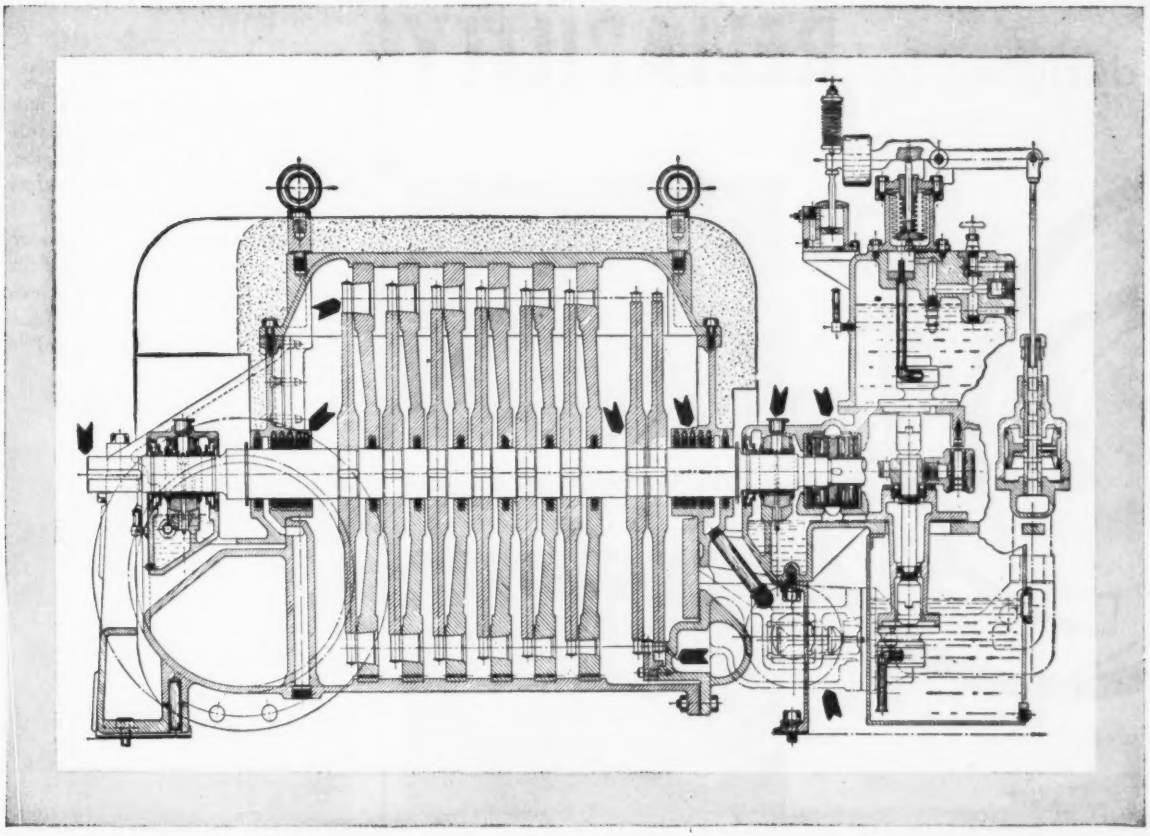
For more details consult the Chemical Engineering Catalog pp. 1035-1038

Bulletins on all CONSECO PRODUCTS *sent on request.*



circle 313 on Reader Service card, p 123



ANOTHER INSIDE STORY OF THE UNIVERSAL ACCEPTANCE OF MURRAY MULTI-STAGE TURBINES IN THE MECHANICAL DRIVE FIELD

- Husky accurately machined shaft.
- Discs shrunk and keyed in place.
- Stainless steel nozzles and blading throughout.
- Spherical seated sleeve bearings.
- Kingsbury thrust bearing.
- Center line support.
- Carbon ring gland seals.
- Double seated balanced governor valve — stellited.
- Choice of speed governors from simple mechanical type to precision oil relay.
- Bolt type overspeed trip governor.
- Steam conditions to 600 PSIG and 750°F.
- Condensing or non-condensing.

Our nearest representative will gladly help you solve your mechanical drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa, for his name.

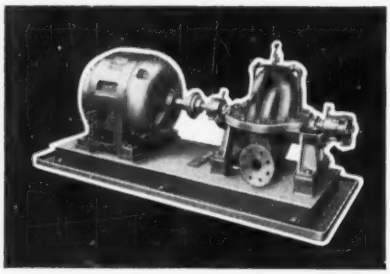
Murray
TURBINES

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA
Builders of Steam Power Equipment for Nearly a Century

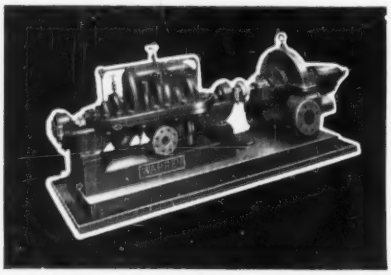
For more facts circle 314 on Reader Service card, p 123

WARREN BOILER FEED PUMPS

designed for RELIABILITY

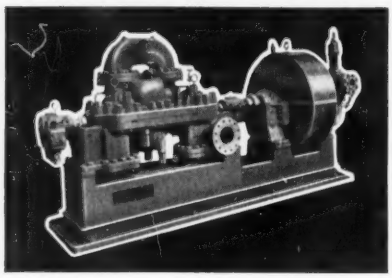


TYPE TL—
up to 400,000 lbs./hr. for 150 psi boilers
up to 400,000 lbs./hr. for 250 psi boilers
ASK FOR BULLETIN 246



TYPE TM—
up to 200,000 lbs./hr. for 400 psi boilers
up to 400,000 lbs./hr. for 600 psi boilers
ASK FOR BULLETIN 241

...and each type is designed for a specific range



TYPE TH—
up to 400,000 lbs./hr. for 900 psi boilers
ASK FOR BULLETIN 244

In the design, manufacture and test of all Warren pumps for Boiler Feed Service, *reliability* is the prime consideration. And when a pump is reliable, you can be sure it will have *low maintenance cost, long life* and *consistently high efficiency*.

Warren's use of modern hydraulic principles and mechanical features is also notable in *special designs* for such services as Low Submergence or High Speeds (over 3600 RPM).

CENTRIFUGAL · SCREW · RECIPROCATING · GEAR

WARREN PUMPS, INC.

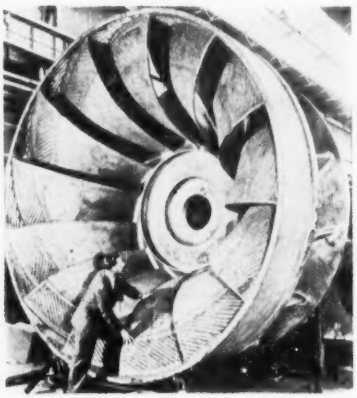
WARREN, MASSACHUSETTS

P-38

For more facts circle 315 on Reader Service card, p 123

for virtually all of the Navy's atomic fleet, including the Polaris-firing submarine, *U.S.S. George Washington*, and the Navy's first atomic surface ship, the *U.S.S. Long Beach*.

Award was established by engineering societies in memory of John Fritz of Bethlehem, Pa., one of America's pioneers in the iron and steel industry who received the first award in 1902.



Hydraulic turbine under way for U.S. Army project

A 68,000-hp hydraulic turbine is almost ready for use at the U.S. Army Corps of Engineers' Table Rock Dam project on the White River near Branson, Missouri. Two 68,000-hp turbines and one 121,000-kva 3-phase forced-air-cooled transformer have already been commissioned from the English Electric Company. A second 121,000-kva transformer is now being completed at the Company's Stafford, England, works.

Milwaukee company uses unique water chiller

One of the first installations of an unusual water-chilling machine serves the main office building of the Milwaukee Gas Light Company. Centrifugal-cooling unit is driven by a piston engine using natural gas as a fuel, replacing customary electric-motor or steam-turbine power source.

continued

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Forge & Fittings Division, H. K. Porter Company, Inc., P. O. Box 95, Roselle, New Jersey
Please send me full literature on your new *Fishmouth*

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You've Got The Job! Here's How to Make It Profitable!

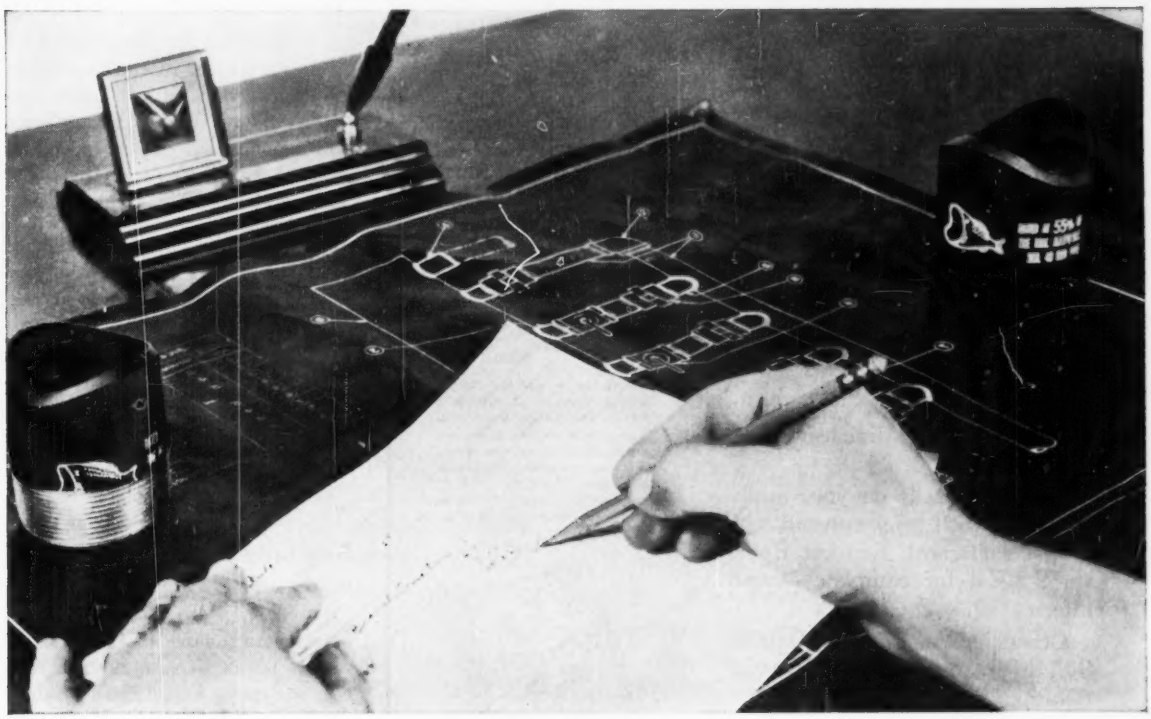
NEW W-S FISHMOUTH BRANCH FITTINGS

Typical Cost: Only 81¢ for 2 inch size for run pipe to 36 inches!

You bid for the job. Stayed late nights to get your bid low. Now the job is yours. But—where's the profit? You have to squeeze on materials and time to make it. Buy cheap—work fast. The old story.

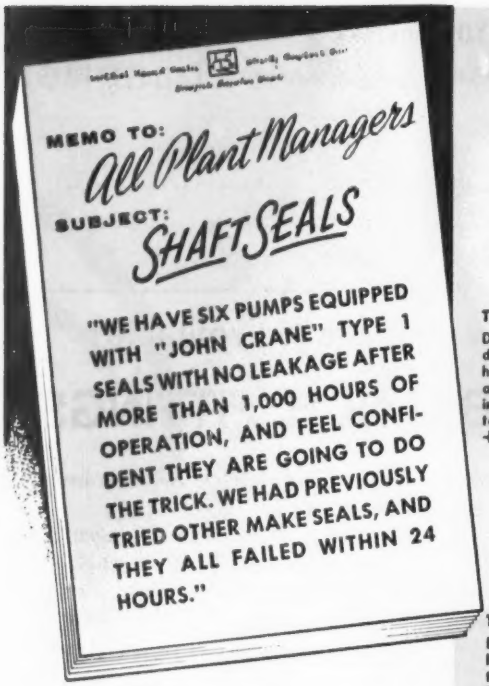
But here's a new story. Figure your branch connections. Lots of them on every job. This new product, W-S FISHMOUTH—figure it instead of the usual tees, laterals, crosses. Savings are almost unbelievable. Makes the difference between breaking even and getting a profit.

If you send us the coupon, you'll learn more. We'll send a 16-page booklet. Tells the whole story. Shows costs for FISHMOUTH vs. other branch connections.

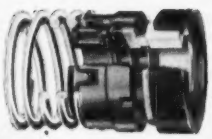


FORGE AND FITTINGS DIVISION PORTER **H.K.PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S.A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

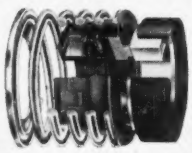

MEMO TO:
All Plant Managers
SUBJECT:
SHAFT SEALS
"WE HAVE SIX PUMPS EQUIPPED WITH "JOHN CRANE" TYPE 1 SEALS WITH NO LEAKAGE AFTER MORE THAN 1,000 HOURS OF OPERATION, AND FEEL CONFIDENT THEY ARE GOING TO DO THE TRICK. WE HAD PREVIOUSLY TRIED OTHER MAKE SEALS, AND THEY ALL FAILED WITHIN 24 HOURS."

John Crane®



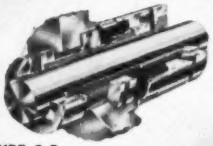
TYPE 1

Designed for limited stuffing box diameter. Handles water, light hydrocarbons, refrigerants, mild acids and other liquids non-injurious to synthetic rubber at temperatures from −40°F. to +212°F., pressures to 200 psi.



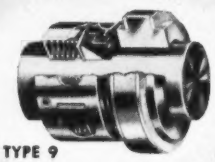
TYPE 2

Designed for limited stuffing box length. Handles same services, temperatures and pressures as Type 1.



TYPE 8-B

Heavy duty, high pressures. Packaged construction for easy installation. Handles pressures to 1200 psi., temperatures from −40°F. to +250°F. Services same as Type 1.



TYPE 9

Famous as a problem solver. Sealing members of chemically inert Du Pont Teflon. Engineered to service conditions to handle practically all destructive acids, corrosives and gases at temperatures from −120°F. to +500°F., pressures to 150 psi. Available in balanced construction for pressures to 750 psi.

This is part of an actual memo sent by one plant manager to others of the same company in different sections of the country—and that company is now exclusively specifying these and other type "John Crane" Shaft Seals for *all* their liquid handling requirements.

You too can save time, trouble and expense by doing likewise.

You'll find a "John Crane" Shaft Seal for every service . . . from hot or cold water to the most destructive acids and corrosives . . . high temperatures, high pressures . . . in types and sizes to meet practically any mechanical or dimensional requirement.

Send us details on your application. We'll recommend the proper shaft seal. Request Bulletin S-204-3 for complete overall information.

Crane Packing Co., 6430 Oakton St., Morton Grove, Illinois, (Chicago Suburb).

In Canada: Crane Packing Company, Ltd., Hamilton, Ont.

John Crane

MECHANICAL PACKINGS

SHAFT SEALS

TEFLON PRODUCTS

LAPPING MACHINES

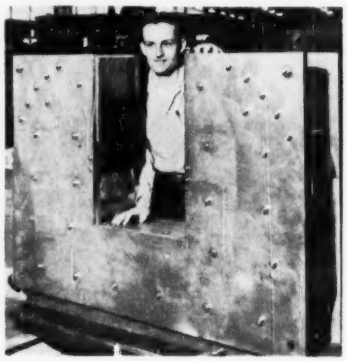
THREAD COMPOUNDS

CRANE PACKING COMPANY

Reports from the field

Begins on page 168

Installed to dramatize gas as an energy source, unit is now air conditioning display areas of the Milwaukee company.



Largest permanent magnet will be used by AEC

World's largest permanent magnet, weighing 1720 lb, is scheduled to work in America's atomic energy program. It will help pump liquid sodium in a breeder reactor to be operated by Argonne National Laboratory for the Atomic Energy Commission. This reactor will produce electrical power at Argonne's Idaho Div site at National Reactor Testing Station near Idaho Falls.

Made by the Arnold Engineering Company of Marengo, Ill., a subsidiary of Allegheny Ludlum Steel Corporation, magnet is constructed of Alnico-V material. Dimensions are 52½ x 36 x 10-in. Density at the center of the gap is 1100 gausses. About 500,000 amp turns were needed to magnetize the unit.

New hot-weather trick: cool yourself a river

Because the summer of 1958 was unusually hot, a General Electric engineer at the Hanford Atomic Products Operation suggested that the Columbia River, second largest river in North America, be cooled down. Millions of gallons of Columbia River water are piped through the Atomic Energy Commission's eight reactors at Hanford each day to carry off heat

WHEN FIRST COST IS IMPORTANT "BUFFALO" RADIAL WHEEL FANS

"Buffalo" Type "CR" Radial Wheel Fan

"Buffalo" Radial Wheel Fans combine the low cost advantages of this type design with the highest efficiencies possible with a radial blade wheel. This is a great advantage in applications suited to this fan. These include stoker-fired or pulverized coal boilers. The "CR" is also widely used for handling air with dust loadings in many industrial jobs.

The "CR" combines sharply rising pressure and horsepower characteristics with high static efficiency. Ruggedly-built, it gives long, trouble-free performance under severe conditions. The high pressure and capacity of this fan often permit use of a smaller unit for many direct-connected applications. This results in further first cost savings.

For dependable, stable radial wheel fan performance, investigate the "Buffalo" Type "CR" Fan. It's designed for both constant volume or inlet-dampered operation. Write for full information in Bulletin FD-205.

"Buffalo" manufactures a complete line of Mechanical Draft Fans. Included are airfoil and backward-curved designs, with a broad choice of wheels. For details on the full line, call your nearby "Buffalo" engineering representative. Or write us direct for Bulletin FD-905.

BUFFALO FORGE COMPANY

Buffalo, N. Y.

Buffalo Pumps Division, Buffalo, N. Y.

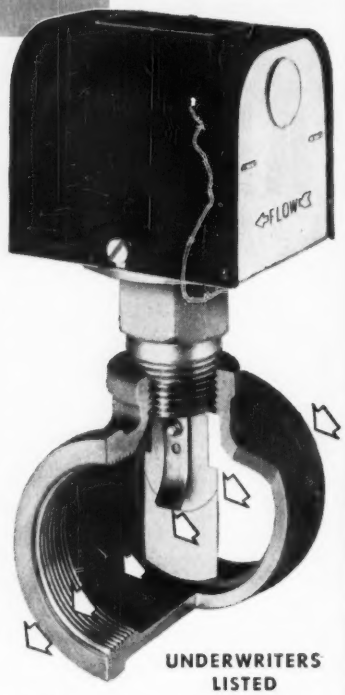
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING • FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING

For more facts circle 318 on Reader Service card, p 123

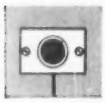
McDONNELL
Flow Switches

FS4 Series Flow Switch shown mounted in a 2 inch Tee

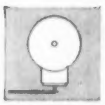


Here's what they do!

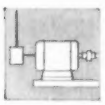
What you see here is a compact, well-built switch that makes or breaks a circuit (as required) when liquid flows or stops flowing. It's an economical and positive way to start or stop anything electrically operated. Just to highlight a few uses:



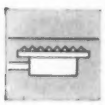
to actuate a signal light—signal an attendant to make the right moves in operating valves, pumps and the like—signal him when flow stops in a water cooled compressor, water cooled bearing and so on.



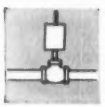
to sound an alarm—when flow stops in a process system or in any water cooled devices.



to start or stop motors—start pumps in sequence in multiple stage flow systems; start standby pumps; stop automatically controlled units if cooling water system fails; stop compressors in cooling systems when flow stops.



to start or stop automatic burners—start a booster heater when water draw occurs, stop burner if flow is improperly retarded; make sure of circulation in a boiler before burner is permitted to start.



to actuate metering device—open valve in chemical feeder line; start mixing in secondary line whenever flow starts in primary line.

UNDERWRITERS LISTED

Positive snap action switch. Easy to install and wire. Segmented paddle fits any pipe from 1" through 3". Unit shown handles pressures to 100 psi, temperatures to 300° F., in these types:

FS4-3—SPDT switch. Opens and closes two separate circuits with flow; closes and opens same two circuits with no flow.

FS4—Closes with flow; opens with no flow.

FS4R—Opens with flow; closes with no flow.

NOTE: Model E-2 available for larger pipes, pressures to 150 psi.

McDONNELL & MILLER, *Inc.*
3506 N. Spaulding Ave., Chicago 18, Ill.
Doing One Thing Well

Coupon brings bulletin
—covering design, construction, electrical ratings, dimensions, typical applications.

Please send me a copy of Flow Switch Bulletin FS1-A.

Company_____

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City, Zone, State_____

By_____

Mail to: McDonnell & Miller, Inc., 3506 N. Spaulding Ave., Chicago 18, Ill.

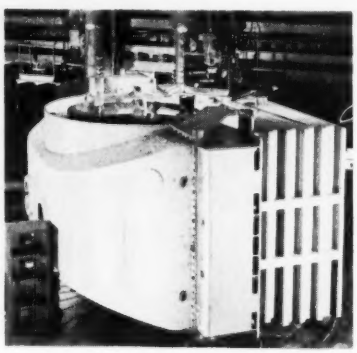
For more facts circle 319 on Reader Service card, p 123

Reports from the field

Begins on page 168

generated by the fission process. For more efficient cooling of these reactors, the water was reduced in temperature from two to five deg by releasing water from the bottom of Grand Coulee Dam instead of over the spillway.

Increased electricity generated at Coulee allowed a larger amount of cold water to churn through the huge generators at the bottom of the dam. This dropped river temperature as much as four deg. Four bypass tubes were opened continuously for 12 days to help the cooling process. With cooperation from the Bureau of Reclamation, the Columbia River cooled down during the past two hot summers.



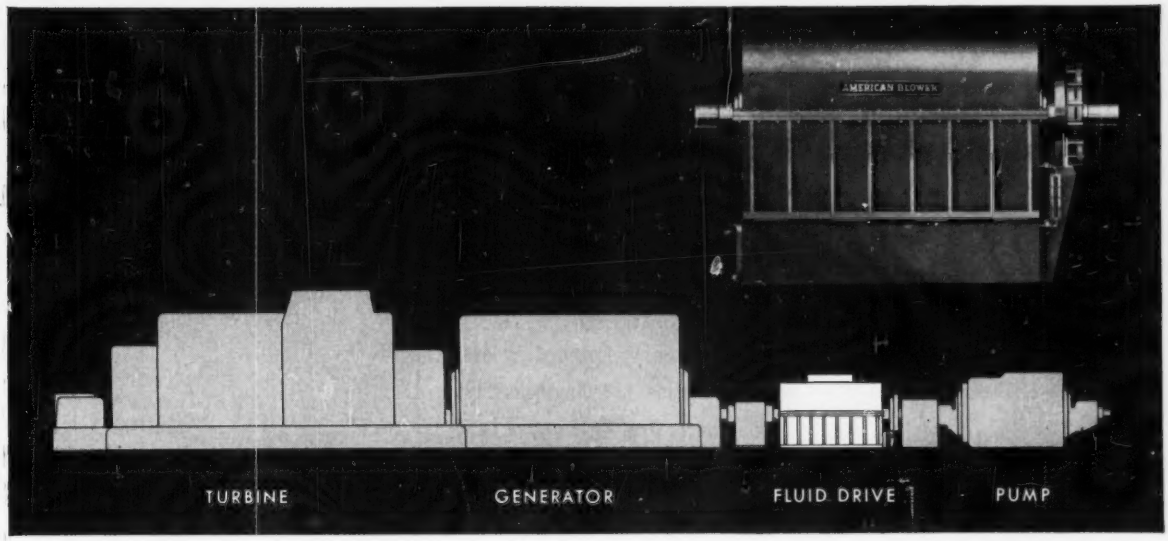
40-ft mill machines l-p-turbine section

A low-pressure turbine for a 340-mw 3600/1800-rpm close-coupled cross-compound steam-turbine-generator unit is shown being machined on a 40-ft mill in Allis-Chalmers shops. Unit is one of two for the Astoria Station of Consolidated Edison Company in New York.

Large heat-pump system now under construction

One of the largest heat-pump systems in the country is now under construction in Huntington, Ind. Heating and cooling system being built by Carrier Corporation will serve a $5 million publishing house for *Our Sunday Visitor*, widely circulated Catholic newspaper. This is the first printing establishment served by a major heat-pump installation.

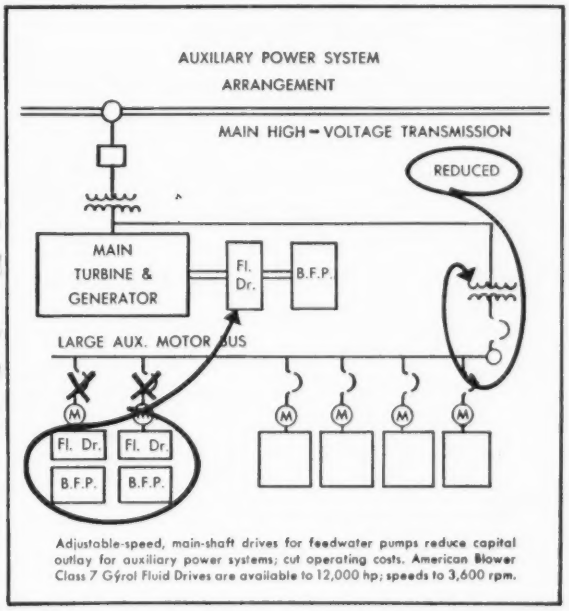
continued



Gýrol® Fluid Drive lets you:

Take boiler feed-pump power from main-turbine shaft . . . slash auxiliary costs!

Save price of motors, switchgear, conduit and cable. Release more power to consumer lines. Reduce operating costs.



Adjustable-speed, main-shaft drives for feedwater pumps reduce capital outlay for auxiliary power systems; cut operating costs. American Blower Class 7 Gýrol Fluid Drives are available to 12,000 hp; speeds to 3,600 rpm.

Savings of nearly $500,000 are predicted for two 290-Mw turbine generator units scheduled for service this year, one of which has been operating since April '59. Both use main-turbine feedwater pumps driven through American Blower adjustable-speed Gýrol Fluid Drives.

Savings are fourfold:

1. **Shaft-end pumps eliminate costly electrical accessories necessary for motor-driven feed pumps.**
2. **Auxiliary demands are reduced, so more power can be released to consumer lines.**
3. **Gýrol Fluid Drive saves power over the entire operating range. It offers adjustable-speed pump control that eliminates wasteful throttling; reduces wear by operating pumps at speeds to fit boiler demands.**
4. **Fluid Drives may effect reduced piping and high pressure heater costs since these auxiliaries may be designed for maximum operating rather than pump shut-off conditions.**

Let an Industrial Division product specialist show you how Gýrol Fluid Drive can save power, cut costs . . . improve operating efficiency. Contact our nearest office, or write: American-Standard* Industrial Division, Detroit 32, Michigan. In Canada: American-Standard Products (Canada) Ltd., Toronto, Ontario.

* American-Standard and Standard are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
INDUSTRIAL DIVISION

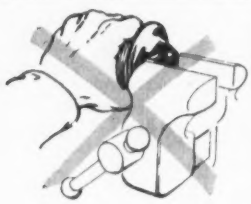
AMERICAN BLOWER PRODUCTS • ROSS PRODUCTS • KEWANEE PRODUCTS

For more facts circle 320 on Reader Service card, p 123

Now . . . from Barnes & Jones . . . the BIGGEST DROP in Steam Trap Maintenance in 50 Years!

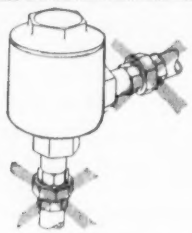
No parts — no assembly.

Barnes & Jones has been recognized for over half a century as a leader in thermostatic traps for the heating trade. Now — the same basic cage unit feature that revolutionized radiator traps thirty years ago is available for high pressure process steam applications.



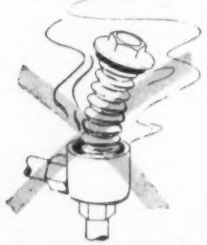
No special tools or shop required.

Now — costly, time-consuming steam trap repairs are outmoded. For with this new B-J Cage Unit replacement, you simply drop a complete new interior into the trap and it's new again. And if steam trap maintenance is a bugaboo with you — it's the best and biggest drop you can make.



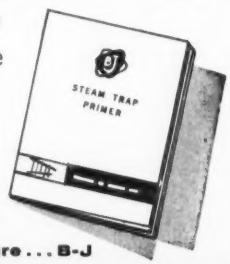
No need of unions.

Also — Barnes & Jones Cage Unit interiors are available to renew other makes of industrial traps.



No over-expansion of bellows.

If you're interested in saving steam, cutting repair and maintenance time and improving trapping efficiency, write today for "The Steam Trap Primer". You'll see the 'hows' and 'whys' of steam trap performances. And perhaps you'll see how B-J high pressure traps and cage units can end your steam trap problems.



Be Wise . . . Be Sure . . . B-J

Barnes & Jones, Inc.
36 Crafts Street
Boston 60, Massachusetts

Reports from the field

Begins on page 168

More kwhr to go to Baja California

A new contract will permit San Diego Gas & Electric Co to sell 60-million kwhr yearly in additional service to CIA Electrical Fronteriza SA in the Tijuana-Tecate-Enseñada triangle of Baja California.

The U.S. company now delivers 100-million kwhr at Tijuana and 600,000 kwhr at Tecate. Tijuana has an 180,000 population and is the company's largest single-meter delivery. Most electricity is stepped down for residential and industrial use. About 5000 kwhr monthly are sent south to Enseñada which has an estimated 60,000 population.

Calendar of Events

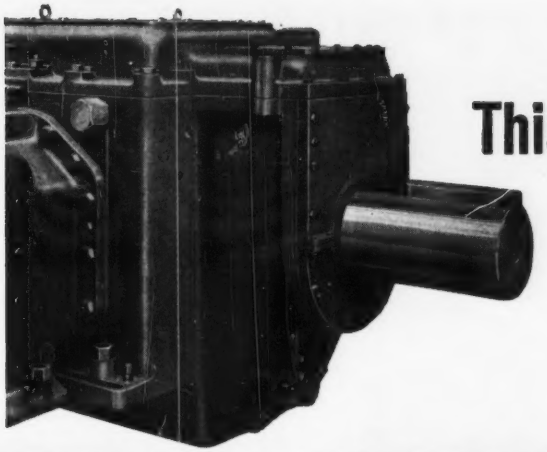
Dec 7-11—National Conference on the Application of Electrical Insulation, Shoreman Hotel, Washington, D.C. Details from T F Hart, Silicones Div, Union Carbide Corp, 30 E 42nd St, New York, N. Y.

Jan 25-28—Plant Maintenance & Engineering Conference, Convention Hall, Philadelphia, Pa. Details: Clapp & Poliak, Inc, 341 Madison Ave, New York 17, N. Y.

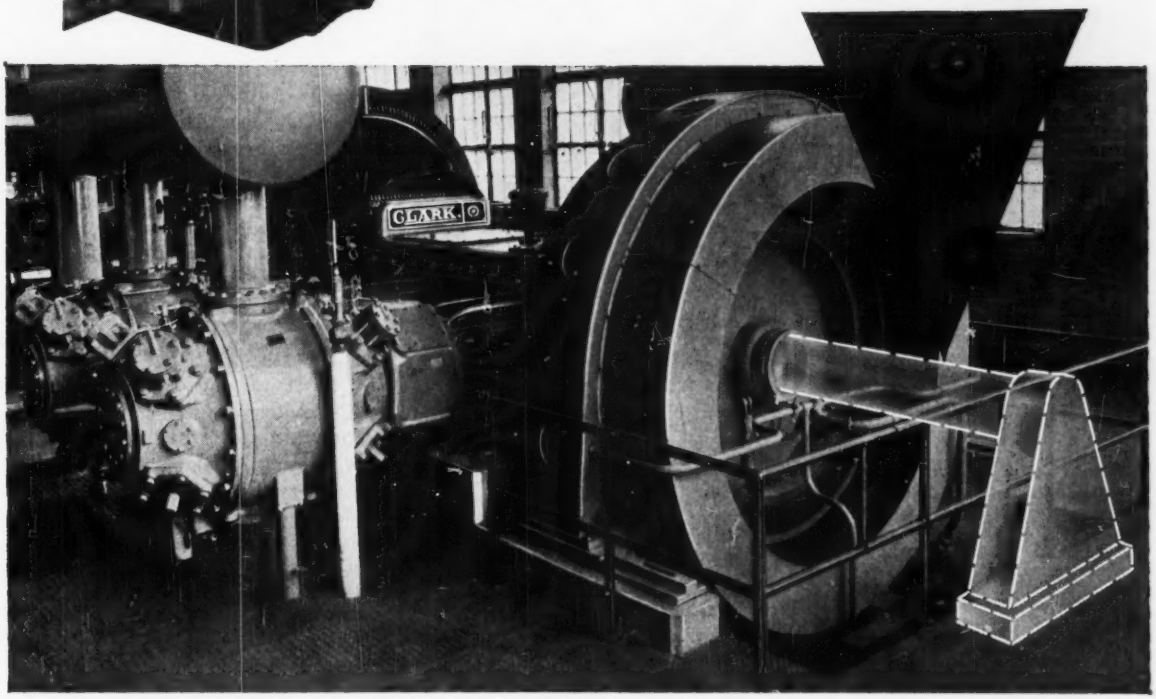
Jan 25-29 — Stress-Measurement Symposium, Arizona State University, Tempe, Arizona. Details from P K Stein, Strain Gage Readings, 5602 E Monte Rosa, Phoenix, Ariz.

Jan 31-Feb 5—American Institute of Electrical Engineers. Winter General Meeting, Hotel Statler, New York, N. Y. Details: E C Day, AIEE, W 39th St, New York, N. Y.

Feb 1-4 — Southwest Heating & Air Conditioning Exposition under the auspices of the American Society of Heating Refrigerating and Air-Conditioning Engineers, semi-annual meeting. Dallas, Texas. Details: E K Stevens, 480 Lexington Ave, New York 17, N. Y.



This Clark development eliminates outboard bearings



In 10 years, in hundreds of installations, NEVER a motor end-bearing failure!

Since Clark introduced *overhung rotor construction* in its Balanced/Opposed compressors a decade ago, hundreds of these air compressors have been built. Proof of the dependability of this design feature is the fact that not one motor end-bearing failure has occurred in over ten years.

Heavy duty crankcases and generously proportioned crankshafts and main bearings are the main reasons for this proved dependability. Here are additional advantages of Clark overhung rotor design:

EASIER INSTALLATION – Mounting the rotor directly on the crankshaft simplifies installation. Just align the stator to the rotor – that's all.

LESS MAINTENANCE – There is no outboard bearing to be knocked out of alignment. Motor bearing is integral with crankcase, lubrication is automatic. Self-centering of the rotor within the stator removes rotor weight from the bearing during operation.

SIMPLER DESIGN – One piece collector rings. Flywheel effect in most instances is completely built into the rotor thereby eliminating the flywheel.

LESS FLOOR SPACE – Close coupling reduces foundation requirements.

Overhung rotor construction is only one of many features found in Clark Balanced/Opposed Compressors. Review your requirements with your Clark representative for all the facts.

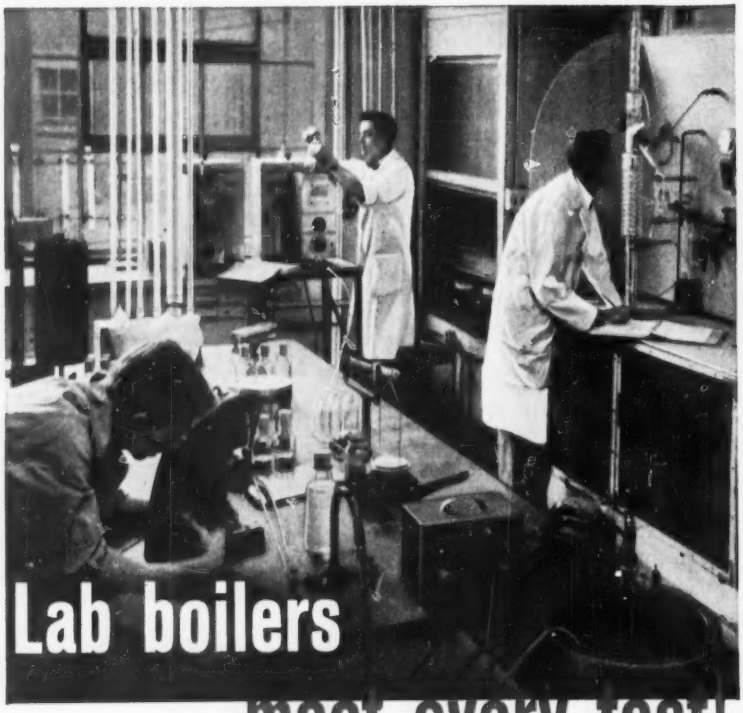
CLARK BROS. CO. OLEAN, NEW YORK

One of the Dresser Industries

ENGINES • COMPRESSORS • GAS TURBINES

CLARK

For more facts circle 322 on Reader Service card, p 123



Lab boilers meet every test!

Two Cleaver-Brooks 150-hp boilers satisfy all demands for steam at Shell Chemical Corporation's Union, New Jersey Technical Service Laboratories

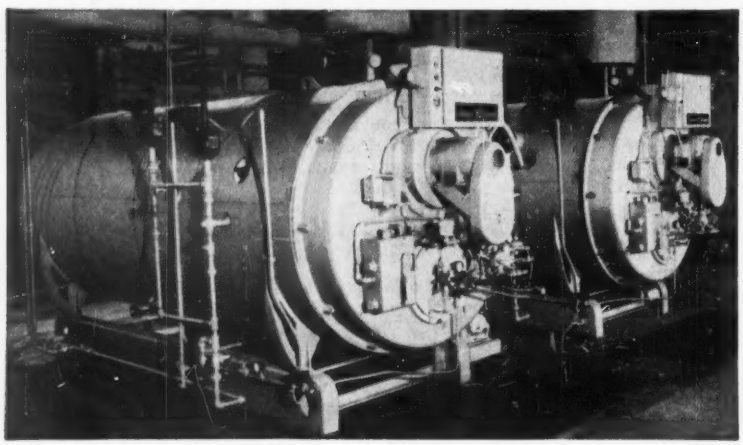
"We find Cleaver-Brooks boilers meet every test we have given them for top operating performance," reports George Baranchulk, utilities and service engineer at Shell's research building. Mr. Baranchulk goes on to say, "There is extreme versatility to our load as our requirements for heating and experimentation may run as low as 10 hp in the summer to over 140 hp in the winter. Checks we have made of CO_2 and stack temperatures indicate we are getting excellent operating efficiency — even when we vary the load over widely separated peak and low demands. These boilers have definitely lived up to every claim you have made for them."

Put Cleaver-Brooks packaged boilers to the test! They are available in sizes from 15 to 600 hp . . . for oil, for gas or for oil/gas combination firing. Contact your representative or write Cleaver-Brooks Company, Dept. P, 301 E. Keefe Ave., Milwaukee 12, Wisconsin.

Cleaver Brooks®

ORIGINATORS AND LARGEST PRODUCER OF PACKAGED BOILERS

TESTING — Fully modulated Cleaver-Brooks boilers burning No. 6 oil supply steam for heating presses, constant temperature rooms, laboratory uses, laminating plastics and air conditioning system. Sold and serviced by Miller & Chitty Company, Union, N.J.



Appointments

Corporation changes

Allis-Chalmers Mfg Co: B S Oberlink, J L Singleton—senior vice-presidents; R M Casper, L W Davis—vice-presidents. **American-Standard Corp:** A Andrews, president. **Astra, Inc:** W P Brobeck, S F Coneybear, board of directors. **Babcock & Wilcox Co:** L M Currie, vice-president. **Burndy Corp:** M Lee, president. **Computer Systems, Inc:** R W Carney, C B Husick, H Zaron—vice-presidents.

Cutler-Hammer Inc: E S Mathiesen, vice-president in charge of manufacturing. **Dunlap and Associates, Inc:** R C Casperson, G Cooper, J H Ely, J T Fucigna—vice-presidents. **Electric Specialty Co:** W E H Reardon, J H Pierson—vice-presidents. **Fairbanks, Morse & Co:** G H Herrick, vice-president and general manager. **Gulton Industries, Inc:** W R G Baker, chairman of board.

International Rectifier Corp: J T Cataldo, senior vice-president. **International Resistance Co:** W W Slocum, president. **Keasbey & Mattison Co:** R R Porter, chairman of board. **Nalco Chemical Co:** D G Braithwaite, executive vice-president in charge of manufacturing. **Philip Carey Mfg Co:** E C Meisner, division vice-president.

Puget Sound Power & Light Co: F McLaughlin, chairman of board. **Radiation Research Corp:** Rear Admiral C F Stillman, assistant to president. **Reading Tube Corp:** M M Rosen, director. **Sylvania Electric Products Inc:** H Lehne, senior vice-president.

Operations changes

Alco Products, Inc: H Schwarz, manager of engineering. **Allis-Chalmers Mfg Co:** H M Raber, works manager of turbines; J A Scoggin, general service manager; R A Heddon, works manager of manufacturing. **Associated Nucleonics, Inc:** S Wallach, manager of theoretical dept. **Daystrom, Inc, Daystrom-Weston Industrial Div:** E C Nicholides, manager of manufacturing. **Dayton Rubber Co:** L I Opper, manager of product engineering.

H K Porter Co, Inc, National

For more facts circle 323 on Reader Service card, p 123

Electric Div: K C Crain Jr, works manager. **Ironton Fire Brick Co:** D R Smith, plant manager. **Minneapolis-Honeywell Regulator Co:** F P Kelly, manager of manufacturing. **Sylvania Electric Products Inc:** S G Lawson, operations manager. **Westinghouse Electric Corp:** W E Hoctor, manager of manufacturing; J W Wilcox, manager of Sturtevant Div. **William Brand & Co, Inc:** A G Schuh, technical service manager.

General sales managers

Aluminum Company of America: E D Verink Jr, chemical and petroleum industry; K Usher, tubular products. **Allis-Chalmers Mfg Co:** J M Duncan, Industries Group; F E White, steam turbine dept. **Babcock & Wilcox Co, Tubular Products Div:** F H Foglesong, alloy sales. **Borg-Warner Corp:** R E Salisbury. **Cooper-Bessemer Corp:** L B Hume, assistant manager.

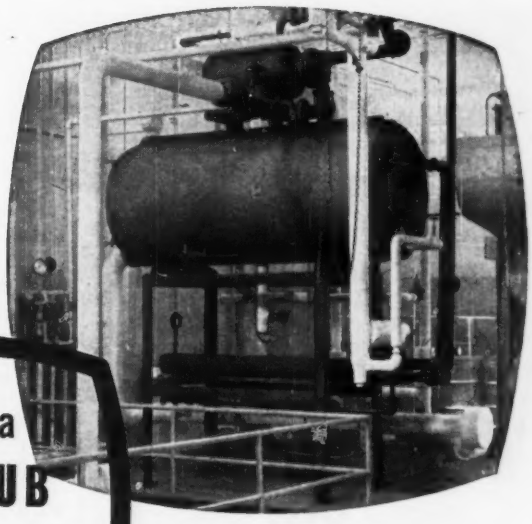
Christie Electric Corp: F Benjamin, Industrial Div. **Detroit Stoker Co:** M J Churchill. **Foster Wheeler Corp:** C P Lattin Jr. **General Electric Co:** L H Hill Jr. **Goodyear Pumps, Inc:** E R Gamiel. **Hagan Chemicals & Controls, Inc:** L M Faulkner; J H Covode, special products. **International Rectifier Corp:** J Conto.

International Resistance Co: R Waldron. **Marsh Instrument Co:** W M Ensign, sales-service manager. **New York Air Brake Co, Aurora Pump Div:** R D Elder. **Southern Electrical Co:** W J Hagan III, director of electrical conductor sales. **Pacific Coast Engineering Co:** A McClure. **United States Rubber Co:** H Davis Jr, mechanical goods div. **Westinghouse Electric Corp:** H W Rainey Jr. **Worthington Corp, Mason-Neilan Div:** J M McAlear.

Sales vice-presidents

Avtron Mfg, Inc: A F Pelster. **Crucible Steel Company of America:** M J Day. **Philip Carey Mfg Co:** A E Binger; C J Bainum; J W Bartlett; W E Hess; G Ellis. **Sylvania Electric Products Inc:** G C Connor.

continued



with a **SCHAUB** ZERO-OXYGEN DEAERATOR

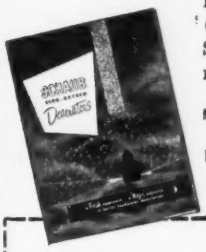
you DON'T NEED sodium sulphite!

True boiler system corrosion protection ...oxygen removal to .005 cc/liter actually achieved under all load variations

The plain fact is, if you have to add something like sodium sulphite to a deaerator for final scavenging of oxygen, you just aren't getting full deaeration. (And you *could* get some bad side effects, worse than the oxygen itself.)

The unique Schaub principle employs 1) external "superheating" to *above* boiling point in the deaerator . . . 2) "explosive" flash-down to release all dissolved gases . . . and 3) fully vented operation. This completely eliminates the air-fill problem and *thermal efficiency compromise* common to all conventional design deaerators using internal heating and restricted vent. *For you* this adds up to *actual* "zero" oxygen removal (to .005 cc/liter) with excellent thermal efficiency under wide load variations — with no need for "additives"

Further, it's a simple, *fully safe* system that takes less maintenance and attention, requires less head room, has fewer internal parts, and no "pressure shell" *insurance premiums to pay.* And exclusive Chromasoid lining guarantees against shell corrosion failure for 10 years!



For new installations or added deaerating capacity (up to 125,000 lbs./hr.) get the facts on the SCHAUB Zero-Oxygen *now* — from your Schaub representative or Write for Bulletin 575.

MAIL THIS COUPON FOR FREE DATA BOOK . . .

FRED H. **SCHAUB** ENGINEERING COMPANY
CHICAGO 23, ILLINOIS

Please send me without cost or obligation my personal copy Bulletin 575 on Boiler Feedwater Deaeration theory and practice.

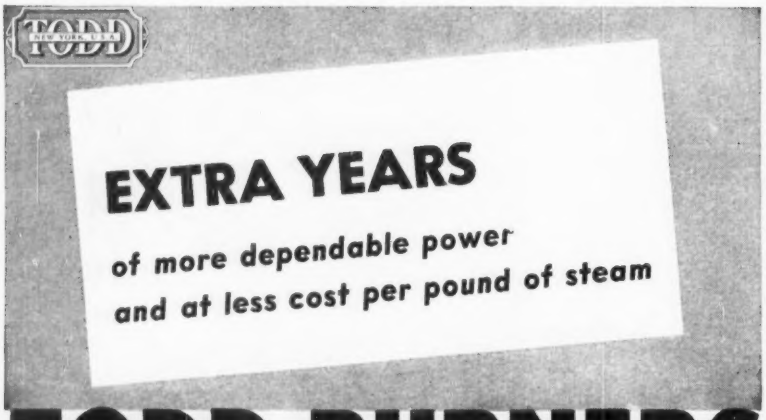
FRED H. SCHAUB ENGINEERING COMPANY
2105 SOUTH MARSHALL BOULEVARD, CHICAGO 23, ILLINOIS

Name_____

Company_____

Address_____

City_____ Zone____ State_____



TODD BURNERS

OIL, GAS, OIL-GAS

TODD

SHIPYARDS CORPORATION

PRODUCTS DIVISION

SALES AND SERVICE DEPARTMENTS
Columbia & Halleck Streets, Brooklyn 31, N. Y.

PLANT, SALES AND SERVICE
Houston, Texas

For more facts circle 325 on Reader Service card, p 123

Robertshaw's Vibraswitch Malfunction Detector
prevents costly machinery damage by actuating an alarm or shutting down machinery the instant excessive vibration occurs. Vibraswitch anticipates trouble caused by failing bearings, bent shafts, broken blades or overspeeding and can easily be installed on pumps and motors, cooling tower fans, compressors and blowers, gas and diesel engines, and turbines. For further detail write for Bulletin RF-586. **Aeronautical and Instrument Division, Robertshaw-Fulton Controls Company, Santa Ana Freeway at Euclid Avenue, Anaheim, California**

Appointments

Recent purchases, mergers

Allis-Chalmers Mfg Co: plans to acquire Valley Iron Works Co. **American Machine and Metals, Inc:** purchase of Automatic Devices Co, Inc. **Bruner Corp:** subsidized by Hagan Chemicals & Controls, Inc.

C & D Batteries, Inc: purchased by Electric Autolite Co. **Cooper-Bessemer Corp:** proposed purchase of Rotor Tool Co has been made. **Crane Co:** purchase of Chapman Valve Mfg Co. **Electric Storage Battery Co:** plans to purchase Atlas Mineral Products Co. **General Waterworks Corp:** proposal to acquire Frick Co has been made.

General Mills, Inc: acquisition of Magnaflux Corp. **H K Porter Co, Inc:** acquisition of Peerless Electric Co and Hill Transformer Corp. **Houston Instrument Corp:** merger with **Crump Instrument Corp. Penn-Union Electric Corp:** purchase of Western Insulated Wire Co.

New names

BICC-Burndy Ltd: jointly owned by Burndy Corp and British Insulated Callendar's Cables Ltd; will manufacture and sell Burndy electrical connectors in the British Commonwealth. **Consolidated Electronics Industries Corp:** consolidation of former Consolidated Electronics Industries Corp and Philips Industries, Inc. **Conveyor Belt Service, Inc:** will provide repair and reconditioning service for eastern industry. **Dean Hill Corp:** new name of the former Dean Hill Pump Company, Inc.

Epoxylite of Canada, Ltd: will supply epoxy-resin compound to the Canadian market. **Garlock de Mexico:** new subsidiary of The Garlock Packing Co to manufacture mechanical packings in Mexico City. **Motores Cummins Diesel do Brazil Ltda:** subsidiary of Cummins Engine Co, Inc in Brazil will produce major parts for firm's diesels. **Norton International Inc:** new corporate name for Norton Behr-Manning Overseas Inc. **Solid State Electronic Controls, Inc:** new subsidiary of Controls Company of America in Tempe, Ariz. **Union Car-**

For more facts circle 326 on Reader Service card, p 123

Begins on page 188

bide Consumer Products Co; new operating division of Union Carbide Corp.

Institute elections

Association of Consulting Chemists & Chemical Engineers: C Bussow, president; E W K Schwarz, vice-president. **American Society of Civil Engineers:** F A Marston, president. **National Insulation Manufacturers Association:** E H Luchs, president. **American Society of Mechanical Engineers:** W L Cisler, president.

Awards

Dr Charles D Coryell, M I T Professor of Chemistry will receive American Chemical Society award for Nuclear Applications in Chemistry. **William A Del Mar,** consulting engineer for Phelps Dodge Products Corp, received the William M Habirshaw Award in Transmission and Distribution of the American Institute of Electrical Engineers. **Dr Augustus B Kinzel,** vice-president of Union Carbide Corp, will receive the Industrial Research Institute Medal for 1960. **Dr Homer Lowry,** coal-chemistry scientist, received the Percy Nicholls Award for outstanding achievement in the field of solid fuels.

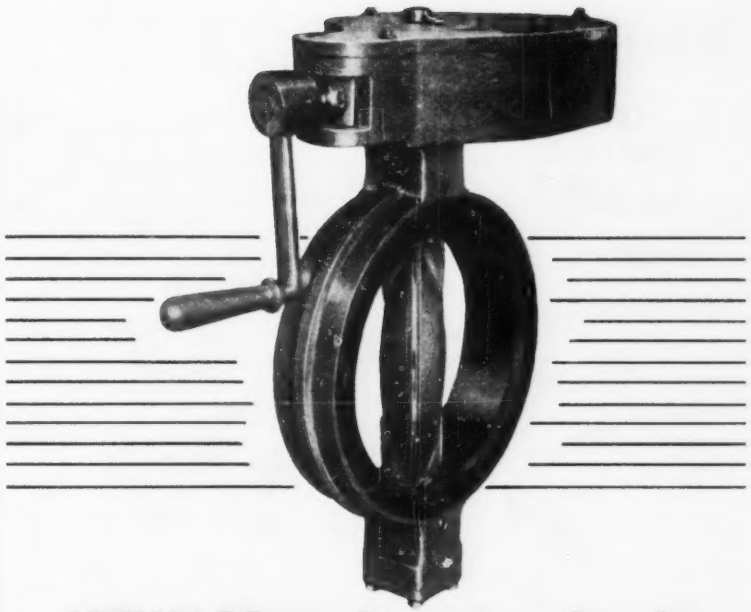
Retirements

Ronald E Heaton, secretary and assistant treasurer of Synthane Corp. **J B Hodtum,** manager of central-station engineering dept of Allis-Chalmers Mfg Corp, after 35 years. **Dr Lowell H Milligan,** associate director of research and development at Norton Company, after 36 years.

Obituaries

Haydn Hungerford, representative for Hungerford & Terry, Inc, on August 21st.

Frederick S Mallette, executive secretary of Air Pollution Controls Committee of the American Society of Mechanical Engineers, on September 10th.



NEW! Monoflange valve is guaranteed drop-tight at 150#

The Henry Pratt Monoflange MK II is a top quality butterfly valve that fits between the pipe flanges of a fluid or gas line. **It saves weight, space and labor** because it eliminates a pair of flanges and requires only one bolting operation. **It eliminates gaskets** because the faces as well as the inside of the valve body are covered with rubber permanently bonded to the metal.

Low torque makes the Monoflange easy to operate, especially with Henry Pratt's **new SIDEWINDER manual operator.** Any type of power operator can be used if desired. Structural features include streamlined disc, one piece shaft, chevron packing and Nylon bearings. Various materials available for corrosive liquids.

Standardized and mass produced, this new valve offers famous Henry Pratt quality at a new low price . . . you can't find a similar valve that offers so much in quality or performance.

Complete information available. Water and gas flow data, valve sizing, operator selection in 26 page brochure. An ideal tool for the engineer working with and specifying valves. Write for Bulletin 10K.

Creative Engineering for Fluid Systems

HENRY PRATT®

Monoflange MK-II
RUBBER SEAT BUTTERFLY VALVE

Henry Pratt Company, 319 W. Van Buren St., Chicago 7, Ill. • Representatives in principal cities

For more facts circle 327 on Reader Service card, p 123

There's no waste water from a V-notch

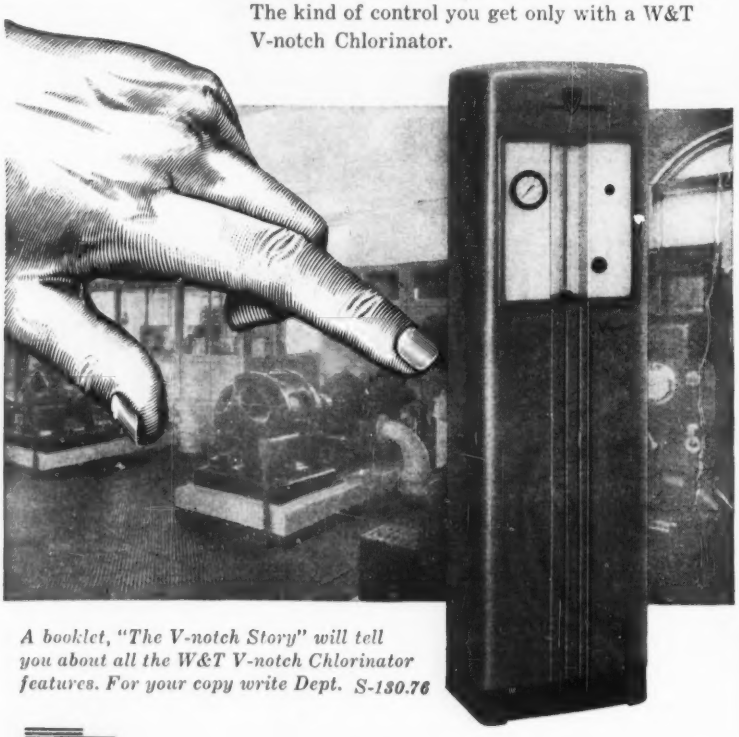
Why?

Because a V-notch Chlorinator needs no auxiliary water supply.

You can plan on clean, dry chlorinator rooms with no messy drain—no chlorine gassing back. And best of all... gone forever is the high cost of wasted auxiliary water.

And, of course, the right plastics make the whole chlorinator chlorine-proof.

Yet these are just added benefits to the main job: Simple, dependable, wide range chlorine control. The kind of control you get only with a W&T V-notch Chlorinator.



A booklet, "The V-notch Story" will tell you about all the W&T V-notch Chlorinator features. For your copy write Dept. S-130.76

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET. BELLEVILLE 9, NEW JERSEY

W&T DRY CHEMICAL FEEDERS

For Accurate Feeding Of Water Treatment Chemicals

Full line of wide range dry chemical feeders capable of controlling a few ounces to 3000 lbs. per minute.

Write for Bulletin M-38 for complete Dry Feeder information.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET. BELLEVILLE 9. NEW JERSEY

Appointments

Begins on page 188

District sales managers

Allis-Chalmers Mfg Co: A E Decker, Eastern area. **American Meter Co:** E B Cutter Jr, Southern area. **Babcock & Wilcox, Tubular Products Div:** T W Wright, assistant manager, New York. **Black, Sivalls & Bryson, Inc:** J Kohl, Western area. **Burroughs Corp, ElectroData Div:** G Lovelace, Boston. **Byron Jackson Pumps, Inc:** E W Stegman, Birmingham. **Cooper-Bessemer Corp:** T M Lamberth Jr, assistant in Southwest; J M Brannaman, eastern Ohio and western Pennsylvania. **Cummins Engine Co, Inc:** C B White, Calcutta, India.

Cutler-Hammer, Inc: E C Bolton, Chicago. **Elliot Co:** G J Greaney, Houston. **Enterprise Engine & Machinery Co:** J E Barthmaier, Northeast. **General Electric Co:** C W Powell, Southern area; G B Cox, New York and mid-eastern states. **R S Hughes Co, Inc:** J Studinger, Colorado; D M Sturm, Seattle. **International Rectifier Corp:** A Scott, Northeast. **Link-Belt Co:** C J Naulty, Southwest. **Philip Carey Mfg Co:** R Wolcott, St. Louis.

SKF Industries, Inc: J O Cushing, Atlanta. **Stone & Webster Engineering Corp:** T E Casselman Jr, New York. **Synthane Corp:** R LeMay, H A Fleer—Chicago. **United States Rubber Co:** J McCarthy, New Orleans. **Westinghouse Electric Corp:** M J Kolasa, Detroit. **William Brand & Co, Inc:** E S Needler, Indiana.

Recent moves

Babcock & Wilcox Co, Tubular Products Div: Oklahoma sales office has moved to Suite 305, 1810 S Baltimore St, Tulsa, Okla. **Electronic Consultants, Inc:** main offices have moved to 156 N Franklin St, Hempstead, N. Y. **Harvey-Wells Electronics, Inc:** firm now occupies new building in Massachusetts Industrial Park, East Natick. **Mercoid Corp:** Philadelphia office is now located at 628 Davisville Rd, Willow Grove, Pa. **Rucker Co:** facilities in Portland, Ore. have moved to 1744 S E Hawthorne Boulevard, Portland.

Bookshelf

Packaged Firetube Boiler Ratings, 1959 Edition. *$1.00. Prepared by the technical committee of the Packaged Firetube Branch of American Boiler & Affiliated Industries, Rm 2502, 15 Park Row, New York 38, N. Y.*

Consulting engineers and architects in general as well as governmental agencies for housing and construction should be interested in this book, which was published as part of a program to promote trade and development of engineering standards, adoption of uniform methods of testing performance, collection and distribution of data and statistics for the industry.

Distinguishing characteristics of the packaged steam or hot-water firetube boiler are defined. A packaged firetube boiler is a modified Scotch boiler, engineered, built and tested by the producing company. Advantages for the buyer of this "undivided responsibility" are pointed out.

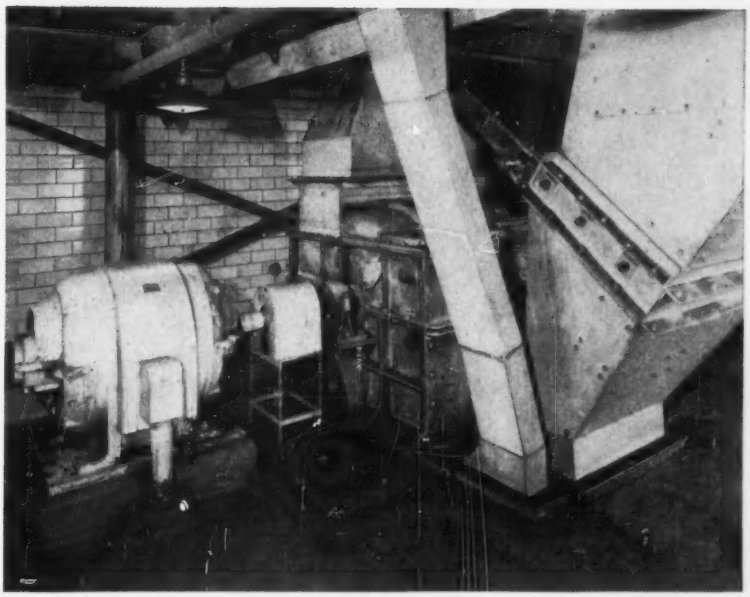
Engineering Economics for Professional Engineers' Examinations. *By Max Kurtz, Consulting Structural Engineer, 260 pages, 5⅜ x 8, 80 illust and tables, $6.50. McGraw-Hill Book Company, 330 W 42nd St, New York 36, N. Y.*

This book is devoted exclusively to helping engineers prepare for and pass the engineering-economics section of PE exams. It brings together facts, formulas and tables that can help save time and insure accuracy in answering most questions on this subject.

All important aspects of engineering economics are covered, including the media of investment, time value of money, sinking funds and annuities, amortization of loans, valuation of bonds, depreciation, depletion, annual cost, capitalized cost, cost analysis, Kelvin's law, law of contracts, the construction industry and professional ethics.

Helpful additions are the many exercises and problems which are typical of questions asked in actual PE exams. These are given with answers or worked-out solutions. Graphs are used extensively to illustrate problems and best methods of solution. Important mathematical formulas and tables are provided.

CRUSHING FACTS



American "Rolling Ring" Coal Crusher

splits coal . . . smashes maintenance costs!

In almost five years, the above American Coal Crusher has reduced 1,800,000 tons of 2" x 0" coal to a ¾" x 0" product for a prominent midwestern utility. Since installation, this unit has handled an average annual tonnage of 450,000, with a very low ratio of replacement parts to tonnage. The operating engineer for this utility says, "We have experienced no stoppages . . . crusher operation and maintenance have been very satisfactory."

"Rolling Ring" design makes the difference. Specially designed rotor, consisting of four rows of patented shredder rings, each suspended on a single shaft, rotate freely at a relatively *slow speed.* Coal is *split* rather than smashed. This splitting action saves both power and maintenance, gives more uniform sizing, fewer fines. Rings can be reversed to give extended life.

American has manufactured reduction equipment since 1908 and you can be sure that "When you figure costs, the best results come from American *Rolling Ring* Crushers." If you have a coal preparation problem, why not write today for recommendations and literature. Our highly-trained engineering staff will give you prompt assistance.

American PULVERIZER COMPANY
ORIGINATORS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS
1349 MACKLIND AVE. ST. LOUIS 10, MO.

For more facts circle 329 on Reader Service card, p 123

George Edwards

asks: Why not standardize OE exams?

At the risk of appearing to belabor an old subject, I can't help wondering why the operating engineer's licensing setup continues to be so inconsistent across this country of ours. Why is the examination for a chief engineer's license in one state easier than that for a first-class fireman in another? Why, for example, if a man is a licensed operating engineer in Massachusetts, can he not function in a similar capacity in New Jersey without a re-examination? And why, in some cases, must an operating engineer licensed by a state be re-examined for license by a city within that state?

As I indicated, the issue isn't new. It has been a justifiable gripe voiced periodically by many operating engineers. "Standardize license requirements!" they ask, but apparently no one listens.

Talking with Steve Elonka in New York recently, we got on this subject and Steve told me that he was amazed at what he found when he researched license requirements for his book *Standard Plant Operator's Questions and Answers* recently published by McGraw-Hill. He said the wide differences in examinations just don't make sense.

No one quarrels with a state's or city's right to insure that engineers licensed to operate plants within its jurisdiction are proved capable by suitable examination. But is it necessary to have such a hodgepodge of examination types and levels?

Look at our marine engineers' licensing system. A license issued in any American seaport is acceptable in every American seaport. Why? Because each engineer takes a *standard* examination for each grade of license. Look at our ASME Boiler Code setup. A Code boiler is a Code boiler regardless of its geographical point of fabrication. Too, the Uniform Boiler Laws, as adopted by many states and cities, are exactly that, a *uniform* set of regulations governing boiler operation and inspection.

Speaking of boiler inspection, the National Board of Boiler and Pressure Vessel Inspectors' examination is a *standard* procedure by which men qualify to become commissioned inspectors. Years ago individual areas qualified their own inspectors, but as time went by the National Board exam became the obvious solution to a confusing problem. True, some cities and states have requirements over and above the Uniform Boiler Laws and National Board exam, but these standards are datum lines. Other areas have not yet adopted such standards but I think it's just a question of time.

Standardized examinations for stationary-power-plant personnel couldn't help but benefit both operating engineers and plant management. Setting up such a system would take a little time and some concerted effort, of course, but it could be done.

Power-plant equipment continues to become more expensively complex, so designed to achieve higher efficiency. Perhaps plant management people, ultimately responsible for continued high-efficiency performance of the equipment, might be the ones to spearhead a drive for standardization of examinations for all grades of licenses.

EDITOR'S NOTE: *Anyone interested? If so, we'll welcome, and print, your pro or con opinions.*

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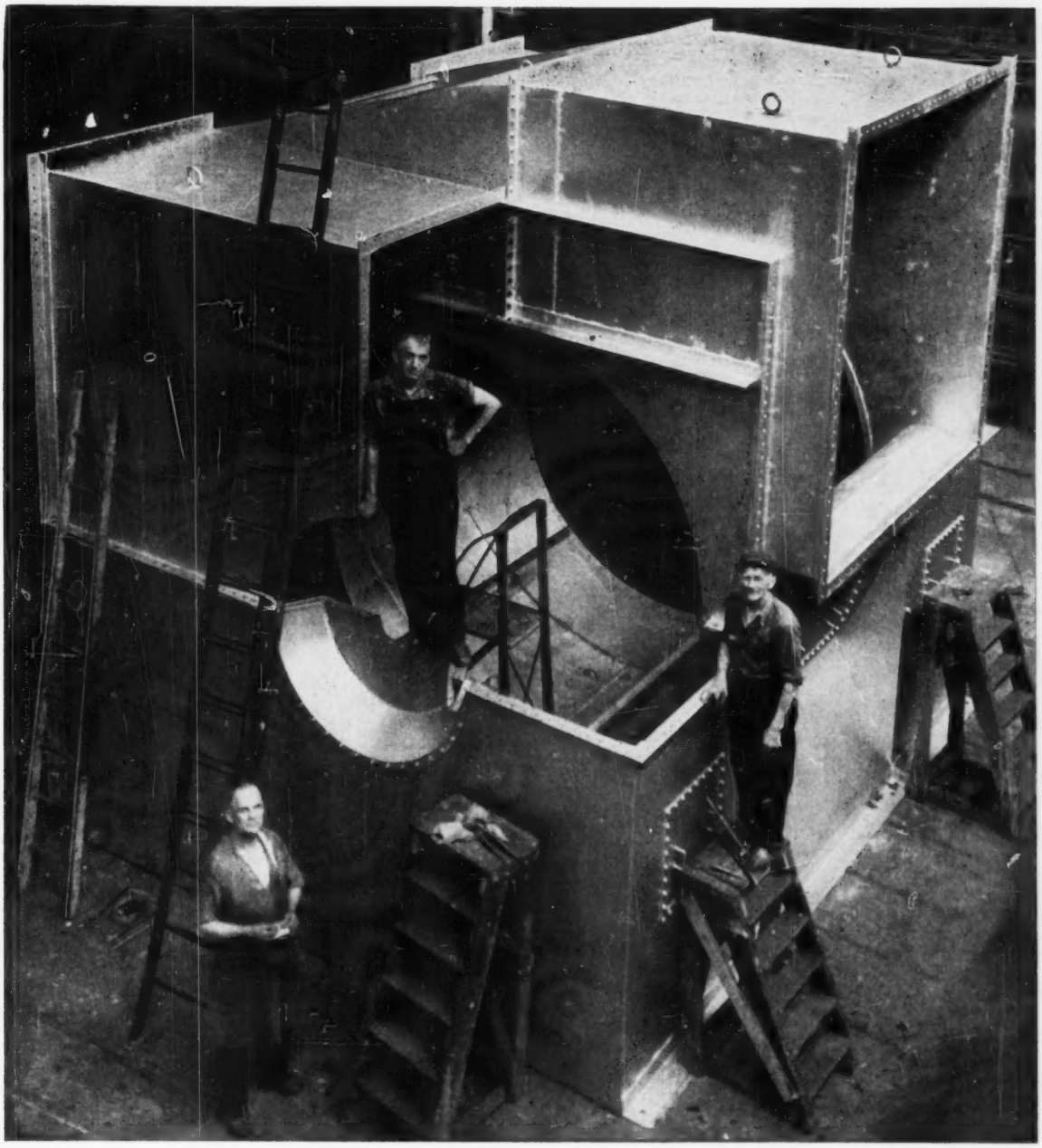
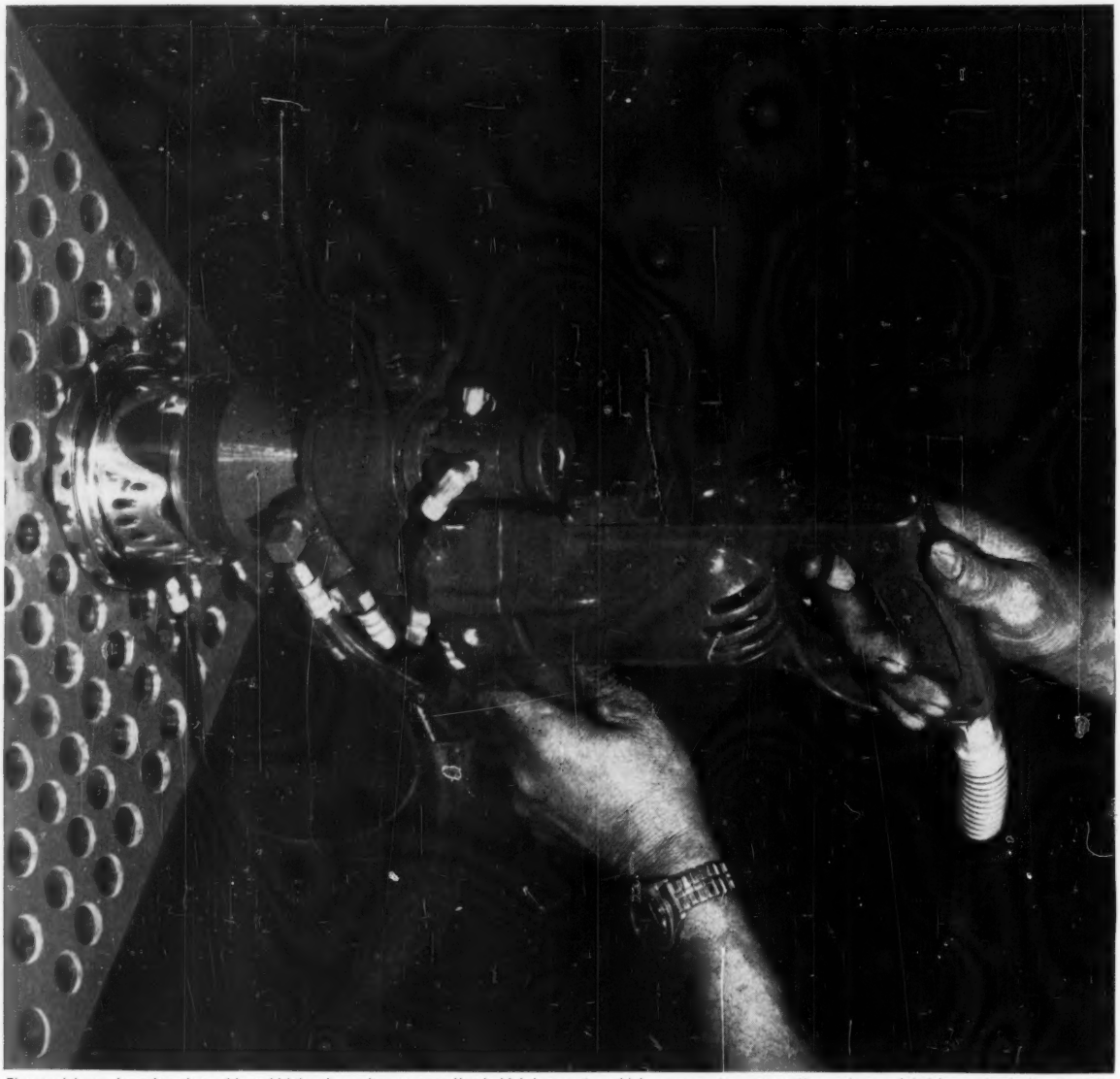


You wouldn't buy a bargain basement parachute... or a cut-rate big game rifle...

Don't choose less than Clarage quality for your mechanical draft service. With anything as vital as uninterrupted operation, it pays big dividends to get the best in equipment. Clarage, a specialist in building forced and induced draft fans, offers you equipment having a long-standing reputation for long-lasting service. CLARAGE FAN COMPANY, Kalamazoo, Michigan.

For more facts circle 330 on Reader Service card, p 123



The special gun shown here is used to weld tubes in condensers operating in high temperature, high pressure steam generating systems, minimizing contamination hazards.

CONDENSER TUBE WELDING INSTALLATIONS MINIMIZE COSTLY CONDENSATE CONTAMINATION

With today's high pressure, high temperature boilers—even more so in tomorrow's nuclear-fueled steam plants—there's no tolerating of condensate contamination through connections at the headers. So next time you re-tube or install original equipment, investigate the welding of tubes to header plates.

Already field-tested and shown to minimize contamination hazards, the welding method of tube installation is now available to you. Chase offers you assistance in making arrangements for the services of a skilled welding firm who will rent you the special welding equipment that is needed, or furnish supervision necessary for installation.

You can get full information by writing to Heat Exchanger Tube Sales, Dept. P129 at Waterbury 20, Conn., or your nearest Chase warehouse or sales office.

Chase

BRASS & COPPER CO. WATERBURY 20, CONN.

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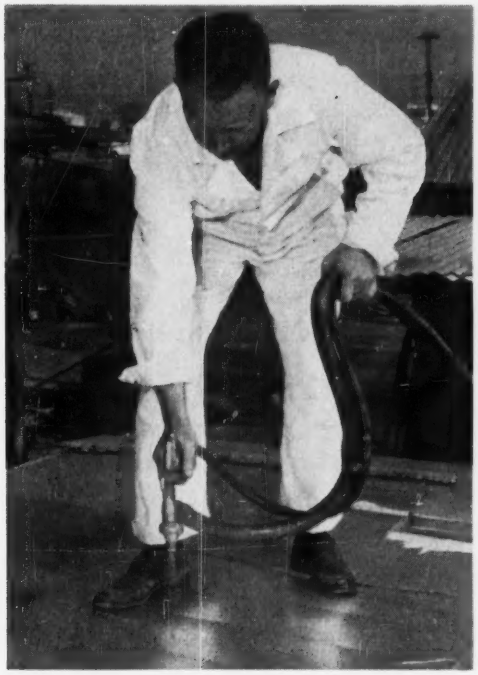
Plant maintenance and management section

STEVE ELONKA
Associate Editor in Charge



MASTIC type coating protects metal against weathering, corrosion, abrasion and moisture. It also dampens sound

WATER-DISPERSED ADHESIVE bonds vinyl-faced fibrous-glass insulation to galvanized ductwork. The adhesive is applied with a brush

You can cut PM costs with... adhesives, coatings, sealers

By R K HUMKE, Mgr
Minnesota Mining
& Mfg Company

Adhesives, coatings and sealers solve many problems in modern industry. Know these materials and the important part they play in reducing preventive-maintenance costs.

Use adhesives to bond insulating and sound-absorbing pads to ductwork, furnaces and air-conditioning equipment. Result: reduced heat transfer, noise and vibration. Coatings not only protect sheet-metal structures from weathering, corrosion and abrasive conditions, but insulate as well. Sealers close openings and gaps in sheet-metal joints against dust, liquids and gases.

Adhesives often replace fasteners wherever a joining or holding job is done mechanically. They distribute the load evenly over entire area. Try them for corrosion protection—their continuous film reduces passage of gases, fluids, moisture and dust between mated surfaces. You'll often cut maintenance with adhesives by doing your job faster—and with a bonus of improved appearance.

Insulation is installed quickly with adhesives. This prevents it from matting and sagging, gives you uniform insulation over entire area. Adhesives are available to bond insulation to ductwork, pipes, furnaces, boiler jackets and blower housings.

continued

SEALER used here is fast drying, tough, rubbery and remains flexible from – 20 F to + 200 F. Apply with brush, gun or caulker

RIBBON SEALER produces a tight, flexible seal that won't shrink or stretch. This one is 100%-solid rubber reinforced with cloth

METAL FILLER sets quickly to a hard yet flexible surface of natural metallic color. It fills cracks, tears and dents on metal

FAST-DRYING wet-strength adhesive bonds board type insulation to ductwork. You can trowel, brush or spray it onto the board

Adhesives do many fastening jobs while coatings prevent corrosion

Several types of adhesives are used for bonding insulation to bare, painted or enameled metal surfaces. Typical insulation materials—glass, foams, glass and cork block, woven-asbestos cloth, cork board, sheet cork, rock-wool bats, rubber, fiberboard and asphalt-impregnated felt pads—are bonded by slow- or rapid-drying adhesives with good immediate strength; from water-dispersed and fire-retardant adhesives to those offering high heat resistance for bonding to high-temperature surfaces.

Solve problems of vibration and thermal loss in thin-metal heat ducts by fastening fibrous-glass pads to ducts with adhesives. This gives complete contact between insulation and metal. Vibration-dampening qualities of pads are fully preserved as adhesives eliminate cutting through or compressing insulation.

Fibrous glass is adhesive-bonded to the sheet-metal outer jacket of furnaces to dampen vibration, keep the jacket from getting overly hot. Fibrous-glass insulation

used here needs a rapid-drying adhesive with good immediate strength, which must also withstand high temperatures without excessive softening or loss of adhesion.

High-density fibrous-glass insulation, coated with a thin film of rubber to prevent air erosion, is applied inside high-velocity ductwork to dampen vibration caused by air rushing through ducts. Apply low-density material to outside of ducts for same reason. For this job adhesives can be used alone or teamed with such mechanical fasteners as clips, taps, staples or cord wrapping.

Coatings add to the life of a part and cut maintenance. They usually have two purposes in power plants: (1) protection against corrosion or abrasion (2) insulation. Their more vital job is acting as temporary or permanent protective barrier between a surface and its surroundings. You can often substitute lower-cost base materials because coatings give extra protection.

Permanent coatings have very good adhesion. They are usually applied in heavy layers to protect structural metal against the elements. Typical of the many permanent coatings for protecting sheet-metal parts against weathering, corrosion, abrasion and moisture is a type based on a selected blend of asphalts and gilsonite. This is applied by brush or spray and sets to a firm, tough film. A thickness up to ⅛-in. on vertical surfaces won't run or sag.

Be sure to protect underground storage tanks, underground pipe lines and bottoms of surface tanks subjected to severe erosion and corrosion caused by electrical and chemical action. A tough, rubbery coating with excellent resistance to water and corrosive soils saturated with sour crude oil and salt water is available. Coatings also protect steel structures such as cooling towers exposed to weather conditions, corrosive chemicals and fumes. A special coating for compressed air seals piping welds and prevents corrosion.

Thermal insulation demands tough, resilient coatings. When sprayed to underside of metal roofs and walls, they retard heat transfer through the metal, reducing condensation and resultant corrosion. As acoustical insulation, sound-deadener coatings can reduce noise level of most mechanical devices. These coatings are especially valuable as sound and vibration dampeners on sheet metal. When they're applied to blower housings on ventilating and air-conditioning equipment, noise is greatly reduced.

Many coatings are available to withstand the corrosive action of chemicals, solvents, salt air and severe exposure. They also protect against abrasion and shock. Some coatings combine surface protection with safety; adding aggregate provides nonslip footing on wood, steel or aluminum construction.

Mastic type coatings have many advantages for insulating. They can be quickly sprayed to cover large areas. More important, you can coat irregular or curved sheet-metal surfaces as easily as flat ones because mastics will adhere to almost any surface. They usually don't need primers or surface treatments. Where higher sound-deadening properties are needed, use these coatings with other acoustical materials to boost the properties of both.

Sealers for power plants have two uses: (1) they close openings and gaps against dust, liquids and gases (2) they provide a vibration- and shock-resistant cushion or a barrier against galvanic corrosion between similar or dissimilar metal surfaces.

Sealers come in bulk or extruded form or as high-viscosity solvent solutions. They can be used with metal, glass, concrete, plastics, wallboard and, in some cases, with wood. They are specialized materials made for extreme temperatures and humidity. Some types resist corrosive environment.

Depending on your needs, you can get sealers resistant to aromatic fuels, oils, water or corrosive chemicals. Others remain firm at high temperatures, still others withstand flexing at low temperatures. Some sealers expand to double their original volume when passed through heating cycles.

Duct sealers stop joints of air ducts, preventing escape of air. They have excellent resistance to water, oil, high temperature and abrasion. Applied by either brush, caulking gun or flow gun, they are fast drying and form a tough, rubbery seal. Use them also to seal expansion joints of either concrete or metal. Duct sealers compounded from polysulfide rubber have tensile strengths in excess of 500 psi. They elongate over 400%. This type of sealer is also used on vibration-isolation joints of generator foundations, as a watertight seal around riveted joints and for patching joint leaks in gas mains.

Tape seal between metal sheets in prefabricated sheet-metal buildings is popular. It also eliminates squeaks between metal sections in equipment that vibrates. This tape is synthetic rubber reinforced with fabric. It contains no solvent so there's little shrinkage. You can buy it in handy rolls of desired width.

Ribbon sealers are used with mechanical-fastening devices. You can tightly seal sheet-metal surfaces fastened with bolts, screws or rivets by applying ribbon sealers to joints before fastening. Ribbon is made of 100% solid cloth-reinforced rubber. It gives a flexible seal that won't shrink or stretch.

Metal-sealer fillers are handy for repairing cracks, tears and dents in sheet-metal surfaces. This species of sealer sets quickly to a hard yet flexible surface of natural metallic color. It has excellent adhesion to steel, aluminum and other metals. Filler can be sanded, primed and painted to make the metal surface look like new.

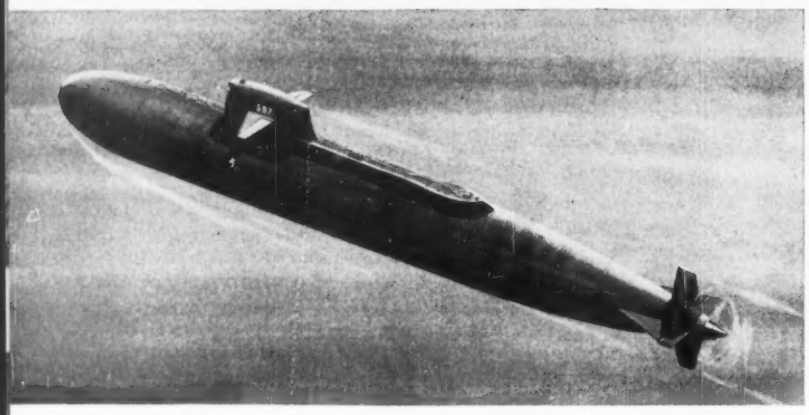
Exterior sealing of vapor leaks on tank-roof seams has been done with a nonhardening synthetic-rubber putty sealer. Besides remaining permanently pliable, it's almost unaffected by age, outdoor weathering, water, gasoline, oil and many other factors.

There's an adhesive, coating or sealer for almost every use in today's industrial plants. The manufacturer's sales engineer is always glad to help with your problems. You'll be amazed at the number of items developed to solve your many headaches. Put them to work—you'll save money and valuable time in the long run.

OPERATORS' NOTEBOOK **134**

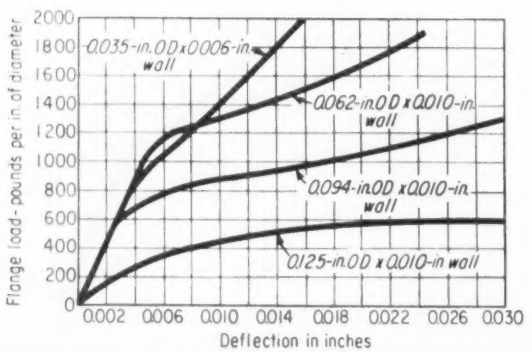
Metallic

VARIETY of sizes and shapes is shown by Douglas Smith, designer of O-rings. Versatile rings seal temp from –420 to 3200 F, give ideal contact: metal-to-metal



ATOMIC SUBS, ballistic missiles and aircraft are biggest customers for metallic O-rings today. But as pressures and temperatures climb, uses are spreading fast

Here's what they are, what they do, and ways to use them



FLANGE LOADING is key to sealing. Curves are based on standard grooves. Don't compress more than 25% of tube's diameter

Higher temperatures and pressures encountered in jets, guided missiles, atomic-power plants and atomic submarines call for heat-resistant metal seals.

Today, metallic O-rings are doing the job for metal-to-metal joints, especially where expansion and contraction of jointing surfaces must be met. These rings seal a variety of chemicals and gases; for example, liquid sodium at temperatures up to 1500 F has been sealed.

Rings shown are manufactured by the D S D Mfg Co of Hamden, Conn., makers of the ballistic-missile couplings we featured in *Notebook* 126, POWER, Feb 1959.

We all know that the perfect seal would be metal-to-metal contact with no gaskets of any kind. But this calls for machining the surface to within a few light bands which usually isn't practical. Then again, heat and pressure have a way of distorting sealing surfaces, and you'll often get movement or 'breathing.' Here is where a metallic O-ring has a big advantage over many other seals.

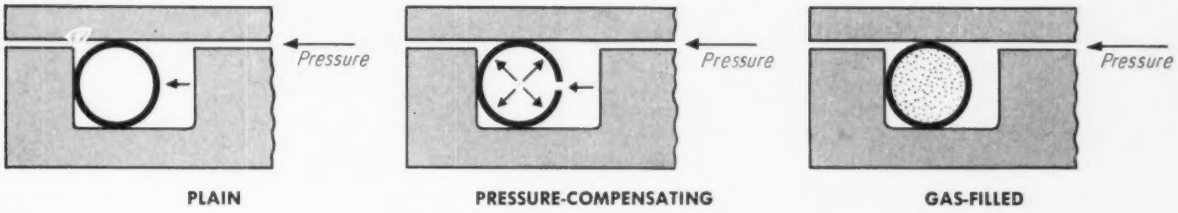
Tubing is made of very thin metal, only 0.006- to 0.010-in. in thickness, resistance welded into rings. External upset is removed to prevent reduction of wall thickness.

Materials used are stainless steel No. 304, 316, 321 and 347; Monel, Inconel and Inconel-X. Rings can also

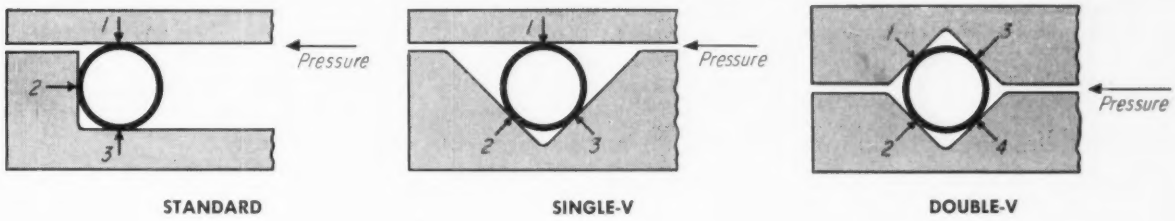
By STEVE ELONKA, Associate Editor

O-rings have come of age

These are the three basic types of rings . . .



. . . and three kinds of ring grooves to receive them



be coated with silver, Kel-F or Teflon. Advantage of silver plating is that it helps the rings seal minute irregularities in machined surfaces. Teflon and other rubber coatings protect rings from corrosion by chemicals.

Three basic types of metallic O-rings are: (1) Plain; about 90% of rings used fall into this group. All O-rings are especially useful where bolt loading is important and therefore weight must be reduced. (2) Pressure-compensating; tiny holes are drilled on ring's inside diameter, through only one wall. Fluid or gas being sealed fills the ring, equalizes pressure on outside and inside of ring. Bolt loading or interference built into the ring does the sealing. These units handle very high pressures, from 4000 to 10,000 psi at present. (3) Gas-filled; here an inert gas fills the ring, at pressures from 300 to 1000 psi depending on service. Important use is where there is flange movement, as from sudden temperature and pressure changes. Gas-filled ring can be reused many times.

Pressures up to 10,000 psi have been sealed; temperatures have run up to 3200 F. If ring is used for a screw fitting, remember to grease it carefully; otherwise galling may destroy sealing surface of the O-ring.

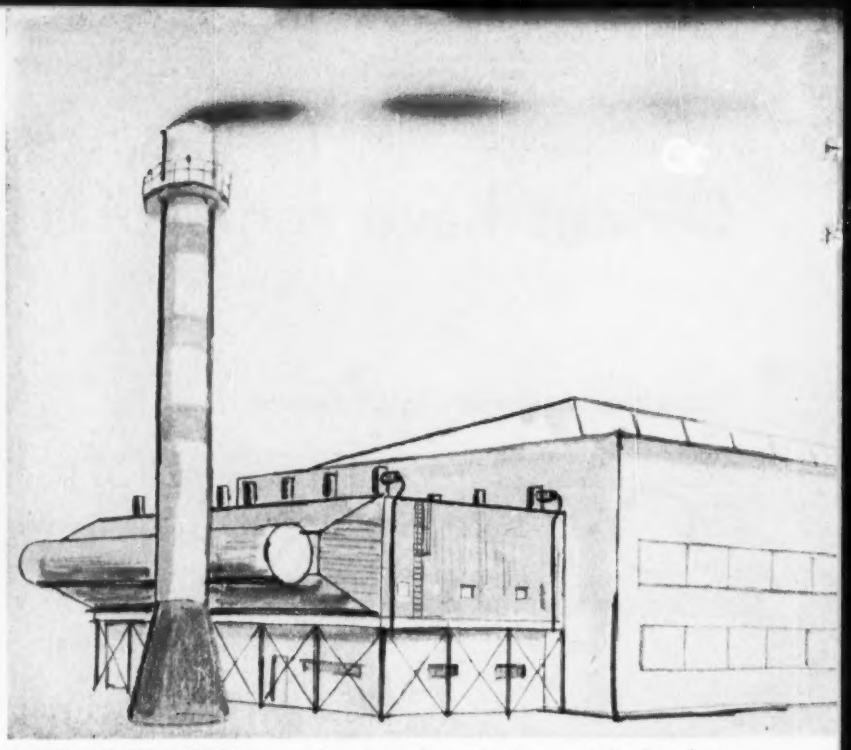
At present rings come in sizes up to 3/8-in. tube diameter and 132-in. ring diameter. Shapes vary widely, as photo shows, depending on job to be done. Biggest user is the aircraft industry, for critical applications.

Flange loading is important when using these rings. Compressive force permissible for rings installed in standard groove is shown in chart, left. Tests indicate that rings can be safely put back into the unit after disassembly as many as six or seven times—long as compression doesn't squeeze ring more than 1/4 of its cross section.

Greatest single disadvantage of O-rings for flanged fittings is that grooves must be machined to receive them. Perhaps someone will come up with a portable tool to cut the comparatively shallow grooves in place—rings are seldom over 3/16 in. in tube diameter.

Experiment. You might be interested in a lab experiment conducted recently. Test blocks were set up to simulate the actual hydraulic valves during flight. An oven was placed over the test device and pressure was changed from zero to 3000 psi, 40 times a minute at 450 to 500 F. Plain rings collapsed after 240,000 cycles. Gas-filled rings lasted 300,000 cycles without failure. Pressure-compensating rings lasted for 500,000 cycles.

RECTIFIER TUBES live longer if you check the filament voltage at regular intervals



"INDIAN SMOKE SIGNALS," or puffing, from the stack often are indicative of too-severe rapping. If your stack puffs, try decreasing the intensity of your rapper operation

A well-designed precipitator will live up to its rating—but only if properly serviced. Here's a rundown on what you should know about . . .

Electrostatic precipitator maintenance

By R L BUMP, Koppers Co, Inc, Metal Products Div

Today's well-designed electrostatic precipitator can boast 99%-plus efficiency. And it will deliver this efficiency day in and day out—provided it gets a reasonable chance to do its job. Like any other fine equipment, your precipitator needs attention at periodic intervals.

Let's take a look, first, at what makes up a precipitator installation. These are its subdivisions:

(1) Electrical system (transformer, rectifier, controls) furnishes precipitator with power to do its job.

(2) Discharge-electrode system is made up of h-v (emitting) elements which cause dielectric breakdown of the gas, ion formation and particle charging. System includes suspension (h-v insulator) arrangement.

(3) Collecting-electrode system has grounded members to collect material after ionization and charging.

(4) Distribution system provides good gas distribution.

(5) Rapping system dislodges collected material.

(6) Dust-removal system conveys collected material from precipitator.

Now let's pinpoint design features of each area and items important for operation and maintenance.

Collecting or "dust" plates are available in variety. Concrete, rod-curtain, double-plate, expanded-metal, V-pocket and ordinary flat plates have been used, as manufacturers strive to furnish most economical arrangement for the particular job. Where collected material is tenacious or other design features tend to reduce re-entrainment, flat plates are selected. If re-entrainment may be a problem, designer picks a more elaborate system. Objective always is a relatively quiet, sheltered area for collection so rapping or gas velocity won't sweep particles back into gas stream. Collecting system needs little maintenance, but these points should be checked: (1) Plates should be properly aligned with discharge electrodes. Plates and wires should be as near center as possible in relation to one another. Remember, one close clearance hinders entire unit's operation. (2) Are plates being adequately cleaned by rappers? If deposits are heavy, try increasing rapping intensity, speeding up the cycle or both.

RAPPER-SEQUENCE AND CONTROL-CIRCUIT checking takes little time. Neglect can have effect on overall performance

ELECTRODE AND PLATE clearances and alignment are important. One too-close clearance can hinder efficient operation of entire unit

If plates are extremely clean chances are they're being rapped too much, aggravating re-entrainment problems. A slight deposit is, as a rule, normal. Be sure rapping system is turned off when boiler is taken off the line. Look for signs of corrosion.

Discharge electrodes, like collecting plates, have assumed many configurations and arrangements. Square, round, twisted, star-shaped, spiraled and barbed are some types used with sizes varying from less than $\frac{1}{8}$-in. to $\frac{1}{4}$-in., materials ranging from lead to stainless steel. But goals to be considered in evaluating design remain basic: Is the wire structurally strong enough to take a beating from the rapping system? Is it efficient in corona emission? Plant engineer must depend on his own experience and manufacturer's know-how.

Good preventive maintenance includes these points: (1) Check alignment. Wires bowed or off center between plates should be straightened or centered. (2) Keep wires as clean as possible, but don't run rappers at such high intensity that wires fail. (3) Keep suspension insulators clean. Moisture and partially conducting dust can cause current leakage and insulator failure with resultant outage for repair. Remember the inside of crock type electrodes is more exposed to dirty gas than the outside; it's usually more important to get the inside cleaned. (4) A potential difference occasionally exists between wires and their guiding gridwork at the bottom, particularly during arc-over when sparking can occur. If difference persists, the wire will burn and fail. Best bet is to have all high-voltage-system connections welded so that the system is essentially homogeneous.

Rapping systems have changed radically in the last decade. Mechanical devices (lifting and dropping plates, swinging weights) have given way to pneumatic- or magnetic-impulse rappers. Modern systems give finer control of rapping frequency and intensity. So there's less over-rapping and re-entrainment. Sectionalization means only a few electrodes are being rapped at any one time.

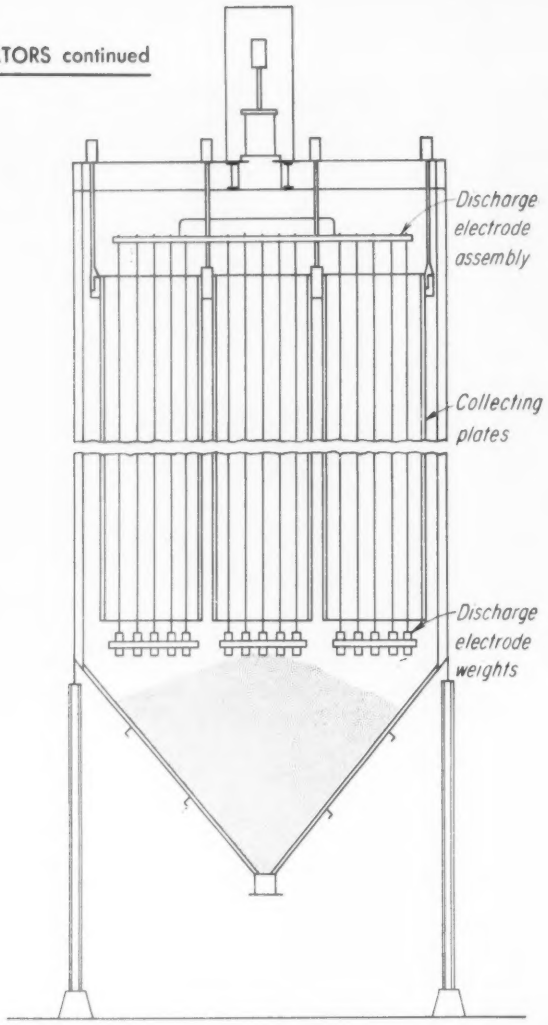
Maintenance ties in with collecting- and discharge-electrode systems. Keep wires clean; slight buildup is OK on plates, so adjust rappers accordingly. Same settings don't apply throughout entire unit—inlet-section electrodes remove much more dust than outlet, need more rapping. If a mechanical collector is ahead of the precipitator, entering dust is finer, has more tendency to pack and will require more-intense rapping. High-sulfur coals generally produce a sticky ash, a much more difficult rapping job. So it's a good idea to keep tabs on the sulfur content of your coal and adjust rapping system to cope with it.

Rapper operation and proper sequencing is obviously a routine matter, but neglect can mean a drop in overall performance. Quality of air supply to pneumatic rappers is very important. Be sure quantity, pressure and dryness are in line with manufacturer's recommendations.

Most rappers are attached to shafts which pass through the precipitator's shell or roof and are sealed by a gland or stuffing box. Shafts should be free to avoid wasting rapping energy.

"Indian smoke signals," or puffing, from a stack ofttimes mean too-severe rapping. Watch for this and reduce rapping intensity. Decrease in the secondary current means insufficient rapping, calling for increased cycle or intensity.

Dust-removal system. Principal method of removing flyash from precipitators still consists of hoppers and vacuum systems. Some precipitators



HOPPERS should not be allowed to fill. This promotes plugging and ash re-entrainment or may short the high-voltage system

use endless-chain conveyors, air slides or hydraulic systems for disposal of collected dust. Moisture content, plugging characteristics and ultimate disposal method usually dictate the way material is removed from precipitator. Important items to remember are: (1) Don't let hoppers fill up. This not only aggravates plugging and rat-holing but decreases precipitator efficiency. Even if dust doesn't build up into the high-voltage system, shorting the unit, ash at top of hopper is continually being picked up by gas velocity and swept out the stack. (2) Hopper vibrators are usually required. If manufacturer doesn't include them in a new installation, it's a good idea to ask him to make provision for them in case of future need. (3) If yours is an outdoor installation, it's advisable to empty hoppers more often, twice a shift if possible, while ash is warm.

Gas distribution plays an extremely important part in operating efficiency. These inspection tips will help spot good or poor distribution: (1) If the precipitator is sectionalized across its width, poor distribution may result if operating characteristics of one section are noticeably different from others. (2) Pitot traverses taken at precipitator inlet during efficiency tests indicate general flow pattern of gas in its approach to precipitator zone. (3) In inspecting a precipitator's interior, it's sometimes possible to get a clue to distribution pattern by looking for areas where abnormally high velocity may have scoured dust from plates or side walls. (4) Actually, checking gas distribution isn't too difficult. It can be done rather readily during an outage with the fans in operation. Using a suitable anemometer, traverse the unit after distribution plates and just ahead of inlet field. Once determined, pattern establishes the basis for corrective measures.

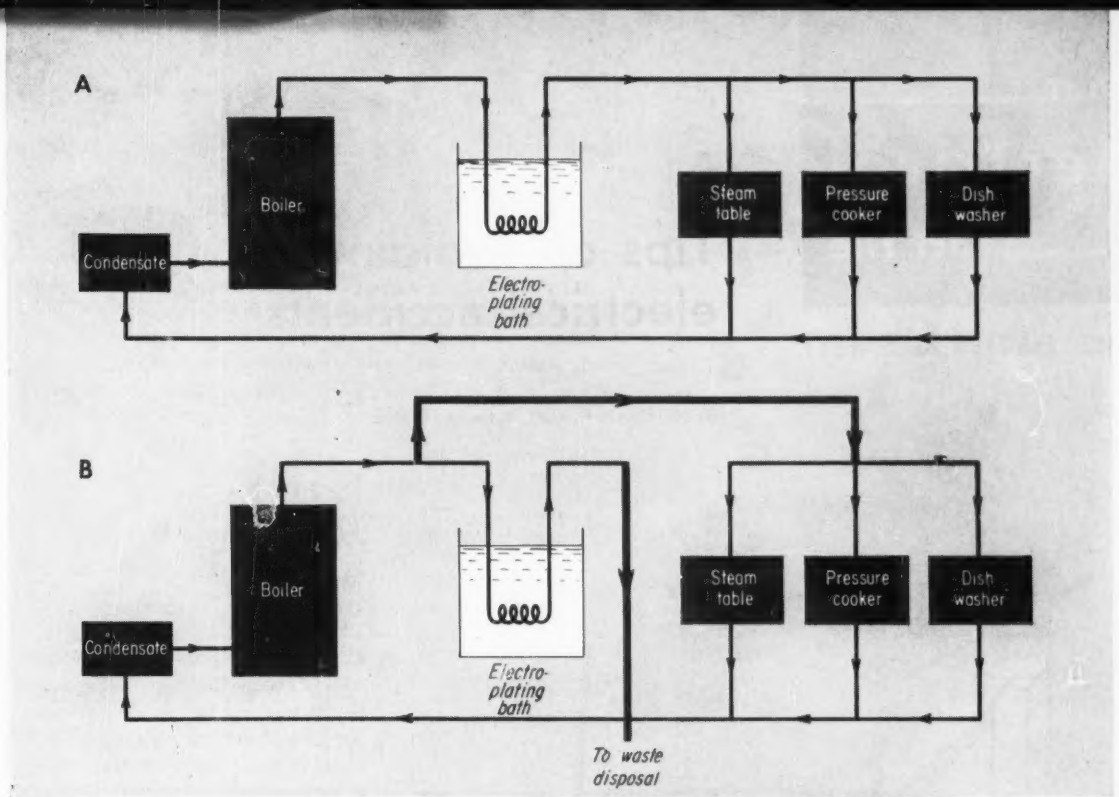
Electrical system is the heart of any precipitator and considerable progress has been made in this area in recent years. Mechanical rectifiers, used almost exclusively until 1947, were followed by vacuum-tube type. Then along came selenium and now silicon rectifiers, which doubtless will soon be in widespread use. New automatic regulators use number of precipitator sparkovers or current drawn by sparkover as triggering element, maintain good electrical operating conditions despite variations in gas volume or composition, dust loading, etc. Most precipitator electrical equipment is trouble-free, but a few points, common to any power unit, should be checked periodically.

Mechanical rectifiers: (1) Spacing between rotor and stator shoes should be maintained between 1/16 and 1/8 in. Badly burned shoes should be replaced. (2) These units usually have manual polarity selection. Be sure that discharge-electrode polarity is negative. (3) Be sure the synchronous-motor-driven rotor is "peaked."

Vacuum-tube rectifiers: (1) Maintain filament voltage so as not to exceed that recommended by manufacturer (usually 20 v). If load permits, operate at less than rating. (2) If line voltage fluctuates, it's advisable to use voltage stabilizers in the tube-filament primary circuit. (3) Severe vibration can murder tubes. If necessary, install shock mounts under tube sockets. (4) If tube cathodes overheat, check load, filament voltage and overcurrent protective devices.

Static rectifier, lacking moving parts and electronic tubes, should be virtually trouble-free. Manufacturers have indicated that rectifier stacks should be practically ageless in precipitator applications.

We've discussed a few basic considerations which can make the difference between good and bad precipitator performance. Any adequately sized precipitator, designed according to accurate specifications, properly aligned and rapped, should do a completely satisfactory job.



These layouts might cause food contamination. How about...

Your steam hookup: A danger source?

By T T PECK, Chief Chemist, Polyphase Chemical Service, Inc

In a large power plant in New Jersey, an engineer regularly draws a water sample from his process-steam boiler and sniffs it for the telltale odor of coffee. In a Pennsylvania syrup-processing plant, boiler-water test kit includes Fehling's solution, familiar to diabetics as a means of testing for sugar. In a wax-paper producer's power plant in Virginia, surface blowdown from all boilers drains to an open tank. Here, it mixes with cold water, floats recoverable paraffin to surface.

Also found in boiler water have been fuel oil, sulfite liquor, soap, chlorinated hydrocarbons, tomato soup, beer and, frustrating situation, traces of Scotch.

Electroplating plants sometimes have boiler water contaminated with cyanide salts. As a rule, this poses no great problem. It's usually a matter of locating leakage source, making repairs, then draining and refilling the boiler with fresh water. However, electroplating in plants having cafeteria facilities requires a hard second look at the condensate-return system. If cafeteria and electroplating department receive steam from a common boiler or battery of boilers, then there's a very real possibility of catastrophe.

Here's how it could happen—and might have in a large plant which, for obvious reasons, must remain unidentified. Drawing *A* shows this plant's steam- and return-piping hookup when presence of cyanide salts was detected in the boiler water. Steam from boiler passes through coil in tank containing cyanide, then goes to kitchen and enters steam table, pressure cooker and dishwasher. Coil develops leak but due to steam pressure no cyanide enters steam line. But, when steam pressure drops to zero and collapse creates a partial vacuum, cyanide solution is sucked into the coil. When steam pressure builds up, cyanide salts or cyanogen gas are carried into the kitchen. A slight residue of cyanide on a kitchen utensil or whiff of cyanogen gas can be fatal.

The plant engineer saw this in a flash. His answer, and the correct one, was to install a small boiler to supply steam only to the cafeteria facilities.

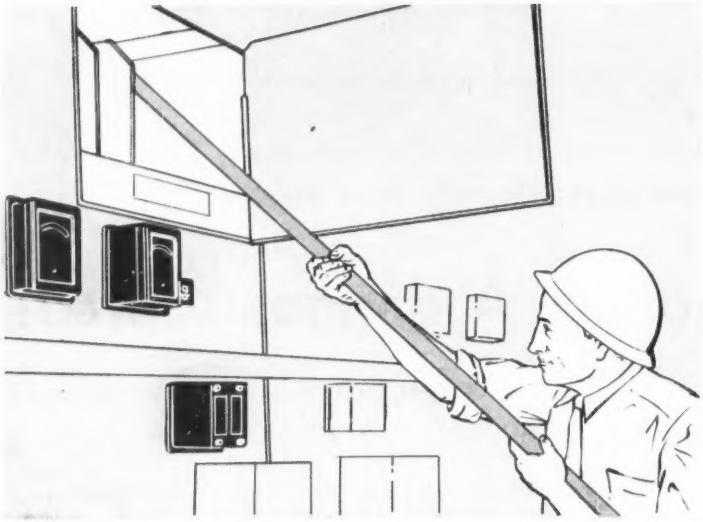
Some will doubtless question this and say, "Why not take steam to the cafeteria from a point *ahead* of the electroplating room and save expense of another boiler?" Well, let's take a look at drawing *B* in which we not only take steam from ahead of the cyanide tank but run returns from the coil to waste. *But*, we still have a disaster potential. A leaky coil could still permit cyanide to be sucked into the steam line and carried back *beyond* where the cafeteria steam line branches off. When steam pressure builds up again, either cyanide salts or cyanogen gas may be shunted into steam going to the cafeteria. Odds are a million to one, but the potential is there. Safest bet: keep all process steam out of the kitchen.

Plant Electrical Fact File

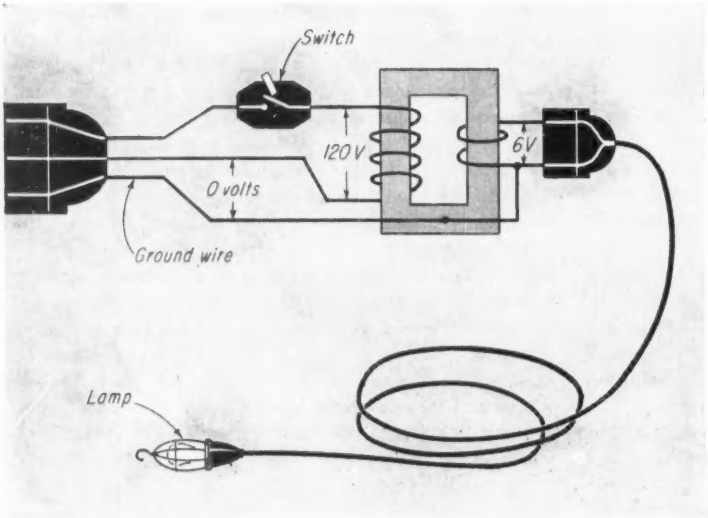
NO. 42: ELECTRICAL SAFETY

Tips on avoiding electrical accidents

By NORMAN PEACH, Associate Editor



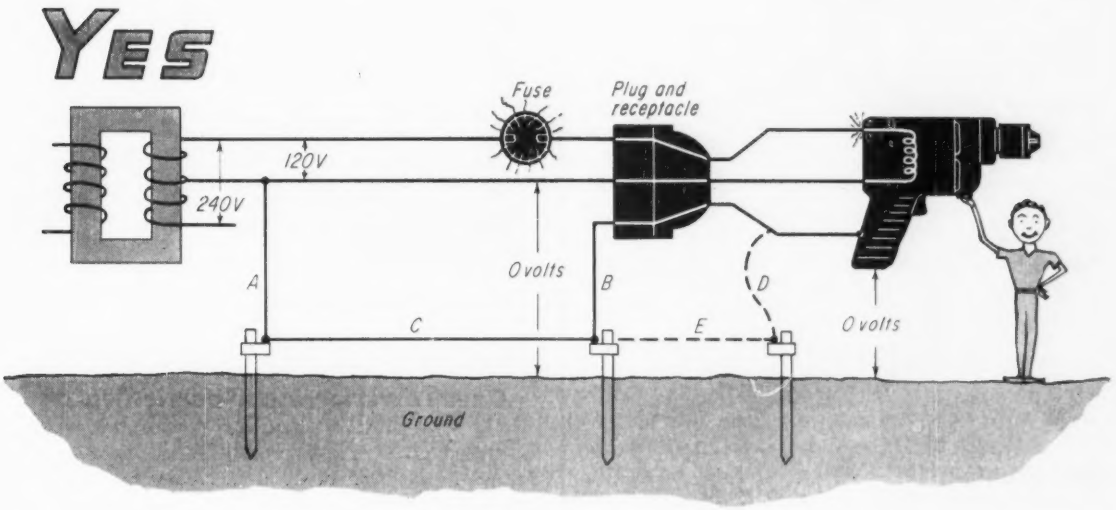
BE PREPARED to work safely. Understand dangers involved in the circuit you're working on: shock, burns, explosions. Safety hats should be made of nonconducting material. Allow space to spring away from accidental arcs. Metal ladders are unsafe for working on lighting or other electric circuits; you may end up with a serious fall if you get a shock. Avoid working around exposed live conductors if you can arrange a way to de-energize them (this is a good rule even for 120 v). Ground de-energized conductors while you're working near them. If you must work around exposed voltages, stand on a rubber mat and use mats as insulating curtains in front of live parts. Wear rubber gloves when you should

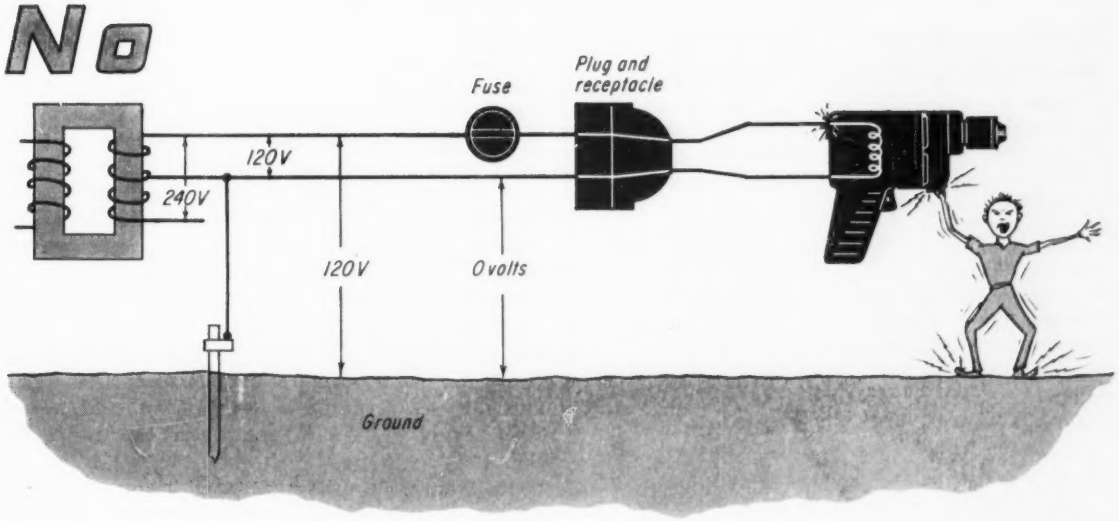


SAFETY LIGHTS are important precaution when working in confined spaces or an atmosphere possibly contaminated with flammable or explosive fumes. Low voltage eliminates danger of shocks and flash burns or eye injury. Possibility of ignition spark is also greatly reduced. Several lamps manufactured are especially designed for this service.

Many safety devices can be designed into electrical installations to prevent danger to personnel. Give a little thought to this during regular maintenance inspection — not only when laying out the plant. Open trolley wires, for example, are a potential hazard; trolley duct can often be substituted. Sources of moisture are another potential electrical hazard

Because someone has taken chances successfully for ten (or 30) years doesn't reduce potential hazard of unsafe electrical practice. Voltages used in power and industrial plants, even 120 v, can kill under conditions where electrical resistance of your body is low. Severe burns or damage to eyes can result from electric arcs or flashes. Recoil from shock or burns can knock you off ladders or back into machines.





GROUNDING of portable tools eliminates one common cause of electric shock. Tools often get rough treatment and in spite of regular inspection, accidental connection between casing and live wire can occur. If tool is properly grounded, current flows to ground and blows fuse. If not, current return path is through *you*. System ground is on neutral wire, *A*. Best scheme has 3-wire plug with permanent ground connection on receptacle, *B*. *C*, *E* are ground bus or conduit system. If plug has no ground wire, make connections as at *D*. Remember: ground return must be continuous, and have low enough resistance so fault current will blow fuse. Check this periodically.

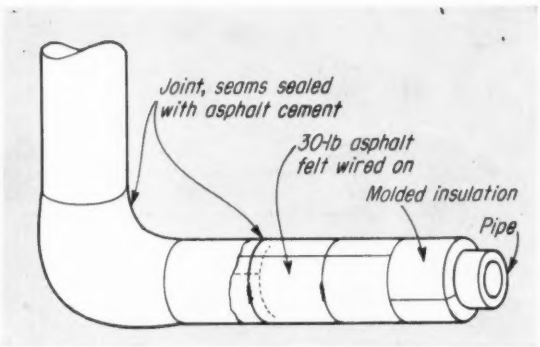
These **plant problems** could well be yours...

The problem

How can we prevent wet insulation in our heating and cooling system?

Insulation on the water piping in our plant is giving us a lot of trouble. We have a year-round heating and cooling system with water at temperatures in the range of 40 to 175 F. One important reason for insulating this piping is to prevent condensation or sweating. Yet the insulation quickly gets wet and has actually fallen apart in several spots. We've tried to patch these sections without much success. It now looks as though all of the insulation may have to be replaced. Is there a satisfactory way of repairing the damaged sections? How can we keep the insulation dry and prevent its rapid deterioration? Any suggestions will be appreciated.—*TG, August* POWER

The solutions



Check exterior vapor-barrier leakage

Insulation problem here probably arises because vapor barrier in the insulation was not maintained as an impervious membrane. Either no vapor barrier was specified, or insulators were negligent in application. Since system is used for 40 F chilled water as well as heating, vapor barrier is the most important part of insulating jacket.

If it has been positively determined that there are no leaks underneath the insulation causing the dampness, try this remedy:

Wait until winter heating load has thoroughly dried out all insulation. If damage has been confined to fittings and valves, it would tend to indicate that a vapor barrier had been applied on straight runs but omitted on valves and fittings. If such is the case, damaged insulation can be repaired, canvassed and painted with two coats of asphaltic roof paint reinforced with long-fiber asbestos.

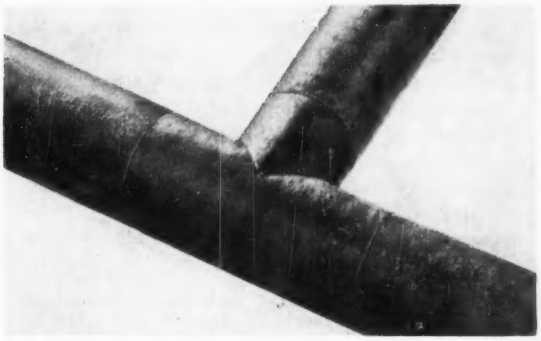
If damage occurs on straight runs as well as on fittings, wrap the straight runs with 30-lb asphalt-saturated felt, wire it on and then paint the longitudinal and girth seams as well as fittings and valves with roof cement. All edges should be coated with cement first and lapped three in.

Success depends upon the thoroughness with which all joints are coated to prevent vapor from passing through the insulation and striking the cold pipe. Insulation must be thoroughly dry before application of vapor barrier to prevent trapping moisture beneath the vapor barrier.

G P DIEGLE, *Marion, Ohio*

...Here's how Power readers would tackle them

LAWSON STEWART, Associate Editor



Use special insulation, properly sealed

TG does not refer to type of insulation that is being used or to method of application. From details he gives it appears that application is at fault. I assume that he is using a good grade of insulation for the pipe which can be bought in preformed sections in either glass fiber, glass foam or a plastic type, all of which suit the range of temperature in which the pipe operates.

Even with good insulation the pipe must be clean and dry before application. Voids between pipe and insulation and all joints and seams should be sealed with a moistureproof mastic which can be bought from a number of sources. Insulation should be sealed completely at joints and seams by "buttering."

Some insulations come with a vaporproof jacket as an integral part. This jacket should be sealed in the same manner. After the insulation and vaporproof jacket are sealed, wire insulation in place with rustproof metal bands or wire three to the section. If the insulation has no vapor-barrier jacket, flood the surface with a coat of vaporproof mastic and apply a layer of open-weave glass fabric. After this preparation, paint or jacket with canvas as desired; insulation should last for some time.

Note that with plastic type insulations, sealers recommended by the manufacturer of the insulation should be used. Insulation can be cut around fittings, joints and valves and applied in the same manner. All pipe hangers should be provided with metal support shields of minimum 20 gage to support pipe load and prevent puncturing or damaging insulation. These shields should be of sufficient size to extend half-way up the pipe and should be a minimum 8- to 12-in. long.

Only reason for insulation becoming wet and falling off the pipe, assuming no leaks, is the fact that insulation was not properly applied and sealed to prevent moisture from migrating from the ambient surrounding the pipework through seams and joints of insulation to pipe surface, at which point it condenses. Once this process is started it gets steadily worse to the point where some insulations deteriorate with moisture and fall away.

If TG's insulation job was not up to minimum standards to begin with, he may have to do the whole job over.

W H CLOEST, *Kingsport, Tenn.*

Install barrier at pipe surface

Trouble is most likely caused by the condensation of airborne moisture on the surface of TG's pipelines. For this to happen insulation vapor seal must be inadequate or nonexistant, allowing moisture to infiltrate insulation and further reduce its insulating value.

This can be prevented by first covering the bare surfaces with a layer of 8- or 10-lb asbestos paper. It should be pulled up snug and lapped about 1 in. on the sides, secured at 6-in. intervals with a turn of fine wire. Next, cover this with heavyweight unbleached muslin, cut into strips from 4 to 6 in. in width and saturated with adhesive paste. Spiral the muslin on with laps of ½-in. or so, drawing it in a direction that tends to compress the underlying paper tightly. When thoroughly dry apply two coats of asphaltum paint and brush it in thoroughly.

TG's pipes are now ready to receive the regular covering. Take care to use only intact sections and to fill all openings between joints with a suitable insulating cement. Elbows and other fittings will require special application of moldable insulation and sealing cement. Joints between block and moldable insulation are trouble spots.

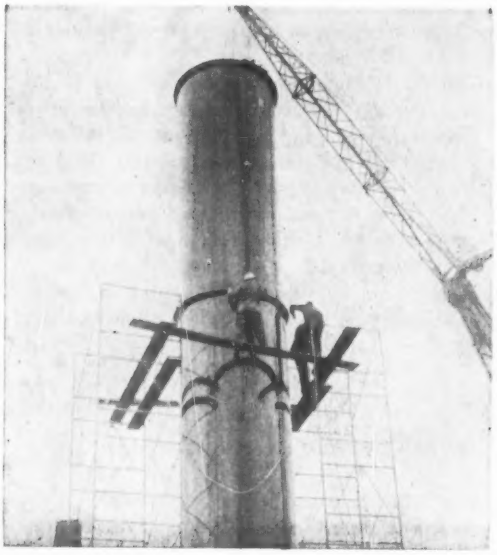
If pipes are exposed to abnormally rough service, an additional covering of 10-oz duck cloth sewed on will afford necessary protection.

For severe outdoor service, another covering of 20- or 22-gage galvanized sheet or aluminum is advisable.

M A JENSEN, *Lincoln, Neb.*

Turn page for new problems ▶

More **plant problems**



The problem

What construction materials are best for our new smokestacks?

Our medium-sized manufacturing plant will soon have to replace two old smokestacks. They have given good service but are now too expensive to keep in repair. As yet we have not decided on construction materials for the new stacks. Materials under consideration include: (1) unlined plain steel (2) ceramic-lined steel and (3) glass-lined steel. We are leaning toward the use of ceramic-lined steel, but would like to have the opinion of readers who have recently wrestled with this same problem. What are the relative advantages and disadvantages of each material? How do they compare in first and amortized cost? What maintenance problems can be expected?—*SM, August* POWER

The solutions

Want some help on plant problems? Send us any of your design and operating headaches. We'll put *Power* readers to work on them

Are large stacks actually needed?

Has our engineer considered overall condition of his steam plant? If his stacks are in need of replacement, what is the condition of breeching and boilers?

Before any move is made to replace the stacks he should review his entire facility. It is my experience that often the installation of a modern packaged boiler to replace existing equipment is most economical. A new packaged boiler with fans and stub stack will do away with the need for stack replacement.

If new stacks are all that can be justified, careful consideration should be given to cost of stack in relation to future replacement or addition of boilers. Relative life of a stack will vary with numerous conditions such as fuel, service continuity, inspection frequency and maintenance. Comparative factors for stacks are below.

On basis of facts provided I would assume a glass-coated steel stack might provide best solution.

Comparative factors	Unlined plain steel	Unlined wrought iron	Plain steel, ceramic lining	Plain steel, glass coated
Cost	Lowest	Two to three times plain steel	Four to ten times plain steel	Two to five times plain steel
Availability	Numerous sources	Numerous sources	Many sources for steel, limited for ceramic	Limited sources
Erection ease	Relatively simple	Relatively simple	Requires firebrick installation unless stack is short permitting precast lined sections	Needs crane space to raise sections as units
Foundation	Use old one	Use old one	Needs modifying or new foundations to carry weight of lining	Use old one with slight modification
Self-supporting or guyed design	Either	Either	Self-supporting	Self-supporting
Interior corrosion	Severe	Partially resistant	Excellent resistance	Good resistance
Exterior corrosion	Requires painting	Requires painting	Requires painting	Excellent, no paint
Maintenance	Continuous	Not too frequent	Yearly inspection	Yearly inspection

K N BANTHIN, *Broadview, Ill.*

Check stack life against plant life

Unlined steel stacks usually offer lowest first cost and greatest operating expense. This design is most susceptible to corrosion and erosion. Thicker steel increases first cost and only lengthens period before failure.

With solid-fuel firing, unburned carbon and ash usually pass through stack causing erosion. Corrosion of stack exterior from rain, snow and dew is a problem with steel construction. Periodic painting is necessary.

Ceramic-lined steel stacks using gunite, brick or other

refractory type materials offer greater resistance to the undesirable conditions described above. However, danger of combustion gases infiltrating into the lining is constant. When this occurs corrosion results. Additional weight of lining increases structural requirements, so you may need more extensive foundations and supports. A stack usually cannot be lined until erection is completed, requiring time and labor, increasing installed cost.

Glass-lined stacks usually have greatest first cost, but least operating expense results from minimum maintenance. This design may be had with both inside and outside glass covering. Corrosion and erosion are cut, so you can use thinner steel with no need to paint. Lighter foundations are permissible. Glass-lined stacks are available with bolted flanged sections, allowing erection with minimum equipment and labor.

Installed cost for the respective stack types depends on diameter, height, accessibility for erection, labor and shipping costs. Cost relations for the three types are: unlined steel stack, base cost; ceramic-lined steel stack, 1.4 x base cost; glass-lined steel stack, 1.6 x base cost.

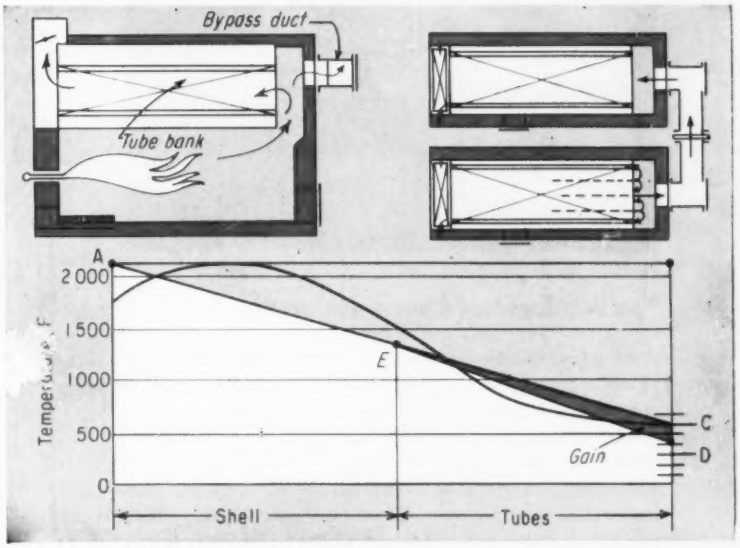
H B WAYNE, *Woodhaven, N. Y.*

Your December problems

Big boner or big saving?

Our plant has two oil-fired HRT boilers, grouped as shown. Each boiler is rated at 100 hp and 100 psig. Pressure is kept between 70 and 90 psig. Full-load flue temperature is 600 F.

During the daytime we fire boiler No. 2 at 4000 to 8000 lb per hr, and during the night boiler No. 1 carries 2000 to 4000 lb per hr. Because of corrosion problems with intermittent load, I have suggested we install a gas duct as shown, right. This would allow us to split gas from burners of one boiler, running part of the flow through each tube bank. We could control gas flow by outlet damper settings and the comparative steam production readings for each unit. With each boiler generating steam, corrosion should be limited.



BYPASS DUCT connecting two HRT units permits splitting gas flow between tube banks. Fuel saving is expected to result from increased absorption at lower tube-bank gas flow

Based on the following reasoning, I believe we may expect a 5% cut in our $40,000 annual fuel bill. This saving of $2000 would more than cover the estimated $200 duct cost.

I arrived at this figure by drawing the diagram, above. For simplicity I disregarded heating area of back tube sheet. Estimated temperature vs gas travel is plotted for present full load and for split gas flow. Shaded area represents heat transferred to water. Small wedge represents added absorption due to gas's having twice the time and heating area for transfer. We estimate new flue temperature will come halfway between 600 F and boiler temperature of 300 F, or about 450 F. Absorption equates to about a 5% boost, which should show up as 5% less fuel at full load.

Before we try this idea out, we would like to know from POWER readers: 1) Has anyone tried a similar setup? 2) Is the reasoning logical? 3) Is estimated 5% saving close to what we can expect?—*AVW*

What is the best kind of wiring for our plant?

We plan to renew electrical wiring in older plants fabricating moderate-sized metal parts. Processes include stamping, machining, degreasing, plating. We will use 4160 v for primary distribution and large motors, 460 v for smaller motors, 460/265 v for fluorescent lighting.

We are considering insulated aluminum aerial cable for 4160-v lines, aluminum bus duct and copper cable in troughs for lower voltages. Can readers make suggestions on how this system works out? How did they avoid corrosion problems with aluminum and copper junctions? Does system involve new maintenance procedures that will boost costs?—*JME*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches.

Timely **practical ideas** to help solve

You readers have been asking for . . .

a complete question-and-answer guide to operating the power services. Now here it is, twenty books in two volumes, with 385 illustrations. The 20 chapter headings: boilers (*Code* requirements, fans, feedwater treatment, brick walls, etc), steam engines, steam turbines, pumps, instruments, miscellaneous problems, electricity and vacuum tubes, refrigeration, diesel, air conditioning, fuels and firing, compressed air, heat exchangers, gas turbines, cooling towers, building heating, nuclear power, lubrication, safety, and 54 pages of latest license requirements in U.S. and Canada.

These books are the result of numerous letters to POWER editors. They will help: (1) plant and building operators and others to pass examinations and improve their basic knowledge (2) industrial and utility firms that have a training program for upgrading employees (3) license examining boards (stationary, refrigeration, diesel, building operators, etc) as a source of questions in one reliable, up-to-date set (4) schools, especially short-course cram and trade schools (5) executives and personnel managers, to use as a guide when interviewing candidates for employment or upgrading (6) sales and service personnel, to gain a better background on plant equipment (7) professional and consulting engineers, for reference in many practical areas not usually found in handbooks (8) firemen, oilers, water-tenders, operators and engineers as a study reference for upgrading, for obtaining a license or for passing civil-service exams.

Each chapter has valuable references. *Standard Plant Operator's Questions and Answers* is published by the McGraw-Hill Book Co. Authors Steve Elonka and J F Robinson examine the first volume off the press, above.

You're educated?

Nothing in the world can take the place of persistence. Talent will not; nothing is more common than talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination *alone* are omnipotent.

CALVIN COOLIDGE

Portable pump fills condenser

At times we have to fill the steam side of our condensers with distilled water or condensate used for steam production in the boilers, to test the several thousand tubes for leakage. Problem of finding the leaks is a minor one since the condensate pours out through the leaking tube.

But we can't fill the steam side with water and drain cooling water from condenser while boiler, turbine and generator are in service. The job means taking from 25,000 to 50,000 revenue-laden kilowatts away from our system. So time is extremely important and the permanent pumping facilities we have are far too slow. We needed another pump to pull water from condensate storage to fill the condenser.

Solution? We rigged a pump and motor on a cart, take it to whichever of our three condensers needs testing. Result: job time cut nearly in half; a unit ready for service hours sooner.

A DESTEFANO, *Atlanta, Ga.*

your tricky design and maintenance problems

STEVE ELONKA, Associate Editor

Don't let this happen!

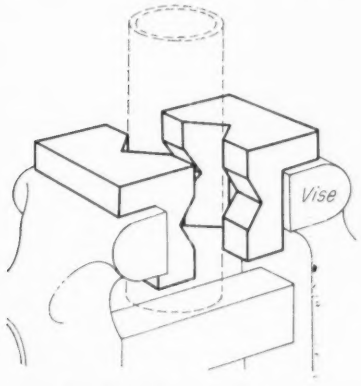
When I was plant engineer at a dry-ice works in Sydney we ordered a 2000-gal tank. This tank was set up on blocks near a cooling-water outlet. Later, tank was filled with 20%-copper-sulfite solution for use as an algae-control agent in the cooling-water system. Then we discovered that the tank manufacturer had closed the 2-in. drain at tank botttom with a wooden bung before shipping.

We had 2000 gal of expensive solution retained by a wooden bung. There was also danger of the bung suddenly loosening, flooding the place with excessive amounts of copper sulfite to give us a real headache.

Fortunately the bung held. We finally strapped it in place with a circumferential band, then rotated the drum with a crane until bung faced up. Needless to say the drum shell was not designed for such rough treatment, so it buckled a little.

We all breathed easier when it was over, and I still remember this as my most anxious experience.

J JOHNSON, *Cronulla, Australia*



Try double V-jaws

These jaws hold round work in either a vertical or horizontal position. You can make them of steel in a milling machine, shaper, or with a drill press and file. Use them singly or in pairs. Once you have them you wouldn't be without them for even a day.

C H WILLEY, *Penacook, N. H.*

What would you have done?

I spent two years aboard a Russian icebreaker above Siberia. We had three triple-expansion steam engines and 12 coal-burning Scotch boilers of 150 psi. We had enough coal, but were down to our last two gage glasses after the first year. Each boiler was already operated with only one gage glass, so we had a real problem. What to do?

The Russian chief engineer removed all the large grease cups from the machinery. Inside each, he placed a float made by soldering shut the two tiny punched holes in empty condensed milk cans. Then he brazed a heavy top to each grease cup, which made them into cylinders. The cans were a nice slide fit inside each.

He fitted one of these cylinders on the upper and on the lower gage glass fitting of each boiler. The floats were coupled together with a $\frac{3}{8}$-in. rod, passing through the screw fittings of the cylinders. Packing nuts were made for the screws and the rods were kept from blowing with packing inside the nuts.

He fastened a pointer to the center of the rod with a scale attached to the boiler shell. When the gage glass cocks were turned on, position of the pointer was calibrated against the water height in the one remaining glass mounted on the other side of the boiler. He scratched a simple scale to show high, low and halfway water level.

Glass in the other boiler mounting was then removed and used only to check accuracy of this homemade gage at intervals.

You might ask why we didn't use the try cocks for determining water level. We tried them, but the fireroom was so cold that the steam issuing from the cocks immediately turned to vapor. So we couldn't be sure of the water level. These floats on all boilers kept us above Siberia for another year before we finally were called into port. What would *you* have done?

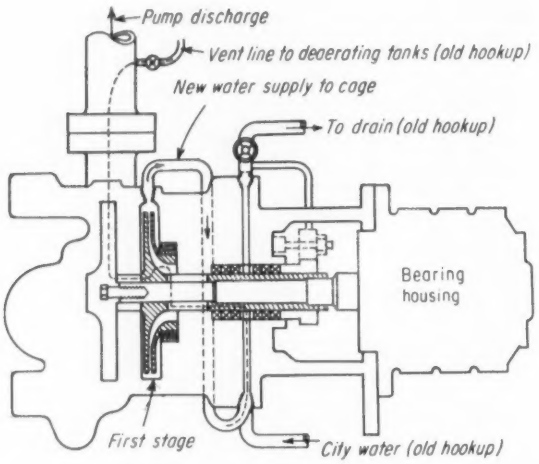
C M JONES, *London, England*

Why not shrink [illegible] heat-exchanger tube ends?

We had trouble removing 1-in.-dia tube ends from 4-in.-thick heat-exchanger tube sheets. Tubes had been rerolled several times so that I was unable to punch them out. Thought I'd have to drill out the tube ends.

To avoid time delay and additional cost, I used a 1/32-in. welding rod, welded a bead along inside of tube for length of tube-sheet section and allowed it to cool. That caused diameter of tube to shrink enough so I could punch tube end out easily.

J MACDONALD, *Sarnia, Ont.*



We cut costly water waste with this hookup

City water was connected directly to the seal cage of a boiler-feedwater pump in our power plant. Water cooled the pump seals, excess discharged to deaerator tank. When the DA tank reached maximum level, it dumped into the sewer. That wasted about 150 gph of expensive H_2O.

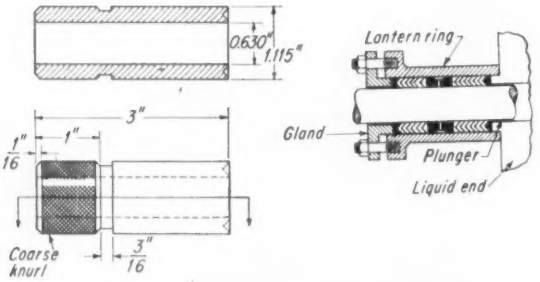
Now we pipe water directly to seal cage from discharge side of the pump, thus eliminating water waste, sketch. Here is our estimated annual saving:

Water per calendar day, 5482 gal	$386.18
Saving in chemicals	346.01
Total	$732.19

Cost of making this change was about one hour's work for one man.

H STAMEY, *Atlanta, Ga.*

EDITOR'S NOTE: *The Owens-Illinois Glass Co awarded Harold Stamey of their maintenance dept a check for $146.34 for this suggestion.*



Now it's easy to pack our pumps

Here's a tool we put together which makes the job of repacking small chemical-proportioning pumps a breeze. Our pumps have stuffing box, see sketch, and use a nested packing.

Tool is made from rolled brass to fit a 1⅛-in. stuffing-box bore and a ⅝-in. pump plunger. After turning, boring, and knurling the tool, cut a "V" in the end as shown. Make edges of the "V" dull. Then split tool lengthwise so packing can be conveniently inserted with pump plunger in place.

F E PEPIN, *Ames, Iowa*

My biggest boner

A friend asked me to help resurrect a dead oil burner in his plant. I took the burner adrift, then cleaned the nozzle tip, dressed up the electrodes and assembled the complete unit in place. The fuel-oil lines seemed all right. Testing the electrical circuit externally I found it complete. 'We should get results now,' I said to myself, so I closed the switch.

The motor and fuel pump ran OK, but no flame. Possibly there was a break in the electrode circuit, so the current wouldn't jump the ignition points. I began checking for this hidden fault.

Opening the furnace door, I put my head in far enough to view the burner. My shoulders blocked out any outside light so all was darkness. I then signaled for the switch to be closed. The spark brightened up the furnace, but nothing else happened. I pulled back out of the furnace and then suggested dipping the storage tank. It was empty, and of course without fuel there was no flame. . . .

Whoa! That last thought nearly floored me. Had I corrected any burner fault . . . had there been fuel . . . I shuddered to think of it.

Since that episode, I test burned electrodes with the burner disconnected from the fuel pump and placed on the floor. I have the highest respect for all hydrocarbon fuels. Never, never again will I go even part way into a furnace to look for the cause of a burner's failure.

F C LOUGHEED, *Vancouver, B.C.*

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Chief Engineer—Fans. Industrial fan manufacturer looking for M.E. experienced all phases fan design for administrative position with unlimited opportunities for salary and management growth. Send resume and salary requirements. P-2949, Power.

Power System Dispatcher. Technical education, age 28 to 40, to dispatch large generating plant loading and 1300 mile transmission system in southwest United States. Plants and transmission system built since 1950. Minimum of five years experience of dispatching work. Send resume of education, experience and salary requirements to P-2940, Power.

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Chemical Engineer desires agency arrangement for heavy engineered equipment in the power field. Presently handling water conditioning equipment. Territory—New England. RA-2963, Power.

POWER EXECUTIVE

A Canadian consulting engineering firm seeks a high level power engineer to take full responsibility for all phases of hydro and thermal power projects. Duties will include preliminary discussions and proposals, liaison with clients, direction and supervision of planning and design, and administrative control of major power projects.

Applicants should be engineers with twenty or more years of experience in the hydro-electric field and should have held positions of senior responsibility. High professional standing and reputation in this field essential. Secondary experience related to thermal plants an asset. Salary open but in keeping with responsibilities and qualifications. Locaton Vancouver.

Replies will be treated in confidence. They should give full personal history and details of education and experience and should state salary requirements. Photograph desirable. Refer to No. 297.

STEVENSON & KELLOGG, LTD.
Member Association of Consulting Management Engineers, Inc.
810 Royal Bank Bldg., Vancouver 2, B.C.

ENGINEERS

To work in the expanding Construction Engineering Division of a multi-plant national packaging company located in Chicago. This division is responsible for all new construction as well as major remodeling to present facilities, located throughout the United States and Canada.

Applicants must have a mechanical Engineering Degree and have experience in the development of building designs and layouts for new or remodeled industrial plants and research laboratories. Major industrial experience should be in the fields of heating, ventilating and air-conditioning. He will be required to layout such systems, consult with architects and contractors and advise and assist plant on these types of problems.

Please send resume.

All replies confidential.

J. H. SAMPSON
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A. C. MOTORS—60 CYCLE

HP	Mfr.	Type	Volts	Speed
800	Whse. (2)	Sq. Cage	2300	1800
750	G.E.	Slipring	2300	514
700	Whse.	Slipring	2300/4000	1200
600	G.E.	Synch.	460	900
600	Elliott (3)	Sq. Cage	2300	900
500	Allis Ch.	Slipring	2300/440	600
400	G.E.	Sq. Cage	440	1200
400	Whse.	Sq. Cage	2300	514
400	Marathon (2)	Sq. Cage	2200	3600
400	G.E.	Slipring	2300	514
400	El. Machy.	Synch.	2300/4000	400
350	Br. Boveri b.b.	Sq. Cage	4800/480	720
350	G.E.	Sq. Cage	2200	1800
350	G.E.	Slipring	440	1200
350	Allis Ch.	Slipring	2200/4000	600
350	G.E.	Slipring	220/440	900
300	Whse.	Synch.	440	1200
300	G.E.	Slipring	220/440	514
250	G.E.	Sq. Cage	2200/440	1200
250	G.E.	Sq. Cage	2200/440	450
250	Gen. Elec.	Sq. Cage	440	3600
250	G.E. TEFC	Sq. Cage	440	1200
250	Whse.	Sq. Cage	2300/440	600
250	Whse. (4)	Slipring	2300/440	600
200	G.E. b.b.	Sq. Cage	220/440	720
200	G.E.	Slipring	220/440	450
200	G.E.	Slipring	440	600
200	G.E.	Slipring	2200	900
200	Reliance b.b.	Sq. Cage	220/440	1800
200	Allis Ch.	Slipring	2200/440	720
200	Whse.	Sq. Cage	2200/440	900
150	Whse. XP	Sq. Cage	440	3600
150	G.E. (4)	Slipring	2200/440	600
150	Cr. Wheeler	Sq. Cage	0/440	450
150	G.E. (2)	Sq. Cage	2200/440	1800
150	Whse.	Slipring	220/440	1200
150	G.E.	Sq. Cage	2300	900
125	A.C. TEFC	Sq. Cage	220/440	1800
125	El. Machy. (2)	Synch.	220/440	400
125	G.E. TEFC.	Sq. Cage	2200	3600
125	Al. Ch. TEFC	Sq. Cage	220/440	600
100	Whse. TEFC	Sq. Cage	220/440	1200
75	G.E. b.b. (8)	Sq. Cage	220/440	1200

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
200	Gen. Elec.	RC	250	1450
75	Allis Ch. b.b.	EB-146L	125	1500
75	G.E. b.b.	CD	250	1750
60	Ideal	D	125	1150
60	G.E. b.b.	CD	600	1750
40	Reliance b.b.	230-T	250	1200

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
250	Cr. Wh.	101-H	230	1150
200	G.E. (2)	RC-38	230	1150
200	Whse. b.b.	8K	250	287/575
150	Rel. TEFC b.b.	2550-F	230	850
150	Whse.	8K-210	230	320/1000
125	G.E.	CD-173	230	575/1150
100	Delco b.b.	late	120/240	1200
100	Elliott b.b. T.E.	JH-FE	230	1150
80	Whse. dyn. b.b.	8K-123L	250	1800/5000
75	Whse. (3)	8K-160	230	550/1150
75/100	Whse.	8K-191	230	300/900
60	G.E. TEFC b.b.	CD-135	230	1150
50	G.E. drip b.b.	CD-1445	230	300/1200
50	G.E.	RF-16	230	250/1000
30	Whse. b.b.	8K-133	230	400/1600
25	Whse. (2)	8K-153	230	300/1200

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V
600	Allis Ch.	440 AC	250 DC
300	Whse. (2)	2200/440 AC	250 DC
200	Gen. Elec.*	220/440 AC	125 DC
125	Gen. Elec.*	2300/4000 AC	250 DC
125	Whse.	220/440 AC	250 DC
100	Delco b.b.	220/440 AC	120/240 DC
75	G.E. b.b.	220/440 AC	250 DC
75	G.E.	220/440 AC	125 DC
60	Allis Ch.	220/440 AC	250 DC
50	G.E. b.b. (3)	220/440 AC	250 DC
35	Reliance b.b.	220/440 AC	250 DC

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SQUIRREL CAGE MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
1250	*Al.-Ch.	ANX	3600
600	West.	CS	720
600	*G.E.	K-63455	1200
500	*G.E.	K-63455	1200
500	*G.E.	I-13-E	900
350	*G.E.	KT-558-A	1800
300	*G.E.	K6344	1200
250	*W (TE)	CS-81205	1800
250	*G.E.	KT-509-S	1800
250	*West.	CS-876-S	1800
250	Brook	RS28	1200
200	*G.E.	FT-549	3600
200	*G.E.	I-K-15B	1800
200	West.	CSP-581-S	1800
200	Brook	RS-27	1200
200	*West.	CS-930-A	900
200	G.E.	KT-564-S	720
200	*Al.-Ch.	AN-37-G	720
200	*West.	CS-1010	600
200	Al.-Ch.	ARW-651	600
150	Cr-Wh.	SC-140	3600
150	Al.-Ch.	AN 30-F	1200
150	West.	CSP-5815	1200

M.G. SETS

Kilowatt	Make	Volts AC	Volts DC
1000	West.	4160	250
750	G.E.	4160	275
500	West.	440	250
400	Al. Ch.	2300	240
300	West.	2300	250
200	G.E.	2300	275
200	Ridgwy	2300	250
150	Al. Ch.	2300	275
150	West.	2300	250
125	Cr. Wh.	4160	125
125	G.E.	2300	250
100	G.E.	2300	250
100	Al. Ch.	2300	250
60	G.E.	220/440	250
40	G.E.	220/440	250

HUNDREDS OF BARGAINS in MOTORS, GENERATORS, CONTROL, HOISTS, COMPRESSORS, ETC.

SLIP RING MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
2500	*G.E.	MT (Mill Type)	257
1100	*G.E.	MT	720
1000	*G.E.	M-575-S	1200
1000	*West.	CW	450
600	*G.E.	M-8843-S	1800
500	G.E.	M-8845	1200
400	*G.E.	MTP-585	1200
350	*Al.-Ch.	ARYW	1800
300	Cr-Wh.	SR-70-R	1800
250	Al.-Ch.	ARY-625	1800
250	*G.E.	I-M-17A	720
200	G.E.	I-M-16	900
200	*West.	CW1950A	514
150	Cr-Wh.	SR-50R	1800
150	G.E.	I-M-15A	600
125	G.E.	I-M-15A	600
100	G.E.	I-E-15A	1800
100	G.E.	MT558	720
100	G.E.	I-M-15A	425
75	West.	CW-770	1200

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ELECTRICAL POWER EQUIPMENT

A. C. MOTORS—3 ph. 60 Cy.

SLIP RING

Qu.	HP	Make	Type	Volts	Speed
1	1750	G.E.	M-579BB	4800/2400	1800
1	1500	G.E.	MT-6	6600	1187
1	800	Whse.	CW	550	1778
1	600	Whse.	CW-432D-15	440	1778
1	500	Whse.	CW	550	350
1	300	G.E.	MTP-581	2300	1800
1	250	G.E.	MT-424Y	4000	257
1	250	Cr. Wh.	SIZE-290	2300	350
1	250	A.C.		550	600
1	250	Whse.	CW-1010	2200	435
1	200	G.E.	IM	2200	580
1	200	G.E.	IM	2200	425
2	200	Whse.	CW-890	2300	1775

SQUIRREL CAGE

2	550	Whse.	CS-1115	2300	900
1	500	G.E.	FT-559AY	2300	3600
4	500	Whse	CS-1216	2300	500
3	500	G.E.	KF	2300	3600
2	450	Elliott	3910BB	2300	1200
2	400	Whse.	CS	4600/4000	3585
1	300	Whse.	CS-1002	2300	600
1	200	Whse.	CS-903H	2300	1175/875
1	200	G.E.	KT-557	440	1800
2	200	Whse.	CS-855S	220/440	1750

SYNCHRONOUS

1	7000	G.E.	ATI	2240/6600	600
1	3500	G.E.	TS-6438P	2300/4000	360
2	1750	G.E.	ATI	2300	3600
1	1750	G.E.	TS	2300	900

M-G SETS—3 PH. 60 CY.

Qu.	K.W.	Make	RPM	DC Volts	AC Volts
2	2100/1750	G.E.	514	250/350	2300/4600
1	2000	G.E.	514	660	2300/4600
1	1500	G.E.	720	600	6600/13200
1	1500	G.E.	514	250	6600/13200
1	1500	G.E.	600	600	2300/4150
1	1200	West.	720	600	2300/4160
1	1000	G.E.	900	260	6600
1	500	G.E.	900	250	2300/4600
1	500	G.E.	900	125/250	440
1	350	G.E.	900	125	440/4160
2	300	G.E.	1200	250	2300
1	300	Whse.	1200	600	2300
1	250	G.E.	900	250	220/440
1	240	West.	900	125	220/440
1	200	El. Mhy.	1200	250	2300/4600

TURBO GENERATORS

Qu.	KV	Make	Desc.
1	300	G.E.	175/200# Cond. 460/2300 V.
1	1000	G.E.	150# no Cond 2400 V.
1	4000	G.E.	400# surface condenser 2400/4150 volts.

TRANSFORMERS

Qu.	KVA	Make	Type	PH.	Voltages
3	3333	Whse.	OISC	1	13800x2300
3	1000	G.E.	OISC	1	13800x460
2	750	G.E.	FYR.	1	55/255
2	500	Kuhl.	OISC	1	13300x6600
3	333	G.E.	OISC	1	7200/12470Yx2400/4160Y

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltage
1	5000	G.E.	60/50/60	11000/6600
2	2500	G.E.	25 cy/62.5	2300/2300

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4 horizontal, 10 vertical, Westinghouse Driving forced draft blowers—capacities ranging from 39000 to 56000 CFM and 16" to 24" pressure. Steam pressures 360 to 575#, back pressure 10#.

Will sell turbines separately if desired.

Price reasonable.

Also—1—250 KW GE turbo generator unit, 3 phase, 60 cycle, 440 volts. Used one year.

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DETROIT 1, MICH.

BOILER

1—Keeler 200 HP, 160 psi, water-tube w/ stokers

COAL PULVERIZERS

1—Babcock & Wilcox #32B, 75 HP

1—Raymond 6-roll mill, 66" dia., 200 HP

3—Robinson #13 Sawtooth Crushers, 15 HP

(4) Fairbanks-Morse 1800 HP Diesel Engines, with 1100 KW DC generators & 1300 HP motors.

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3000 KW GE CURTIS. CONDENSING. 365# ISP. 200° FS 3/60/2300 VOLTS. NEW 1930. FULL AUXILIARIES. BARGAIN.

15000 KW ALLIS CHALMERS. CONDENSING. 250 OR 425# ISP. 700°. 3/60/13200 VOLTS. 1800 RPM. WHEELER SURFACE CONDENSER. AUXILIARIES. NEW IN 1924. IN SERVICE.

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Equipment installed but never used — all built to Navy standards of finest materials

TREMENDOUS SAVINGS ON ALL POWER EQUIPMENT!

PUMPS

10 MAIN FEED PUMPS

PUMP: Ingersoll-Rand — size 5" — three stage — capacity 500 GPM @ 750# discharge pressure. B.H.P 330 — 5000 RPM. *TURBINE:* Worthington-Moore — design pressure 575#/sq. inch — non-condensing — back pressure 20# — 5000 RPM — 330 B.H.P.

GEARED TURBINE-DRIVEN MAIN FEED BOOSTER PUMPS

PUMP: Mfg. by Buffalo Pump Co. — vertical single stage — capacity 550 GPM — 30# discharge — 8" suction — 5" discharge. *TURBINE:* 1 stage impulse — type Y-W — vertical — design steam pressure 575# — back pressure 20# — 12.5 HP — 5500/1750 RPM — mfg by Terry Steam Turbine Co.

2 MAIN FEED BOOSTER PUMPS

Same as geared turbine driven main feed booster pumps above, but with 14.5 HP 440/3/60 AC Star motor & Ward Leonard control. Across-the-line starter with pushbutton.

8 GEARED TURBINE-DRIVEN VERTICAL CONDENSATE PUMPS

PUMP: Main condensate 2-stage vertical pump — mfg by Buffalo Pump Co. *Capacity:* 375 GPM — 70#/sq. inch discharge pressure — 1150 RPM — 22.5 BHP — 9" suction — 4" discharge. *TURBINE:* Single stage — 575# working pressure — 20#/sq. inch back pressure — 22.5 HP — 5360/1150 RPM — Mfg. by Terry Turbine Co.

2 AUX. FEED BOOSTER PUMPS

PUMP: Vertical — mfg by Buffalo Pump Co. — 200 GPM — 30# discharge pressure. *MOTOR:* 7.36 HP — 1800 RPM — 440/3/60 — Star motor, with control.

BRONZE RECIPROCATING STANDBY FEED PUMPS

11 x 8 x 18 — mfg by M. T. Davidson Co. — vertical simplex — capacity 180 GPM — 800/900# discharge pressure — 575# working pressure.

4 TURBINE-DRIVEN FIRE AND FLUSHING SERVICE PUMPS

PUMP: Worthington — horizontal centrifugal. *Fire Service:* 750 GPM capacity — 150 PSI discharge pressure — 3500 RPM. *TURBINE:* single impulse — type B-20 — mfg by B. F. Sturtevant — design steam pressure 575# per sq. inch non-condensing. Back pressure 15# — B.H.P. 80/90.

3 GEARED TURBINE-DRIVEN MAIN CIRCULATING PUMPS

PUMP: Mfg. by Worthington Pump & Machinery Co. — 28" type — vertical single stage — bronze. *Capacity:* 28,000 GPM — discharge pressure 13.5# — 600 RPM — 267 BHP — 28" suction — 28" discharge — 8.5:1 gear ratio. *TURBINE:* single impulse — vertical type — 575# design steam pressure non-condensing — back pressure 15# sq. inch RPM 5100 pinion — 600 gear. Reduction gear ratio 8.5:1 — 267 BHP — mfg by B. F. Sturtevant.

3 MOTOR DRIVEN MAIN CONDENSATE PUMPS

Mfg. by Buffalo Pump Co. — vertical 2-stage — 375 GPM — 70#/sq. inch discharge pressure — 1150 RPM. *Motor Data:* 25 HP — 440/3/60 — 1150 RPM — Star Electric Motor Co. — with across-the-line starter, with pushbutton station — mfg by Ward Leonard.

8 GEARED TURBINE-DRIVEN MAIN LUBE OIL PUMPS

Mfg. by Northern Pump Co. *PUMP:* Vertical rotary type — 750 GPM — 55#/sq. inch discharge pressure — 263 RPM — 35 BHP — oil viscosity 130 to 500 S.S.U. — 7" suction — 6" discharge. *TURBINE:* Single stage — 575# design pressure non-condensing — exhaust pressure 15# — 35 BHP — 26.39:1 gear ratio — 6940 RPM.

4 TURBINE-DRIVEN GEARED FUEL OIL BOOSTER PUMPS

Mfg. by Northern Pump Co. — vertical rotary — 300 GPM — 150# discharge pressure — 282 RPM — 47.3 BHP — Oil viscosity 70-700 S.S.U. — 7" suction — 5" discharge. *DRIVE:* single stage impulse — 575# non-condensing — 15#/sq. inch discharge pressure.

6 FUEL OIL SERVICE PUMPS

Mfg. by Northern Pump Co. — vertical rotary — 85 GPM — 350# discharge pressure — 560 RPM — 27.4 BHP. *TURBINE:* 1 stage — 575# non-condensing — exhaust pressure 15# — mfg. by Northern.

VALVES

THESE ARE JUST A FEW OF THE MANY VALVES OFFERED. ALL TYPES ARE AVAILABLE INCLUDING REDUCING—SENTINEL—RELIEF—MICROMETER—PRESSURE REGULATING — ANGLE, ETC! STEEL—600# SERVICE—SEND US YOUR REQUIREMENTS FOR QUOTATIONS

LESLIE 2" GOVERNOR VALVES

Type C.P. — class A — capacity 7640#/hr. — 575# steam pressure — 750# discharge pressure.

MOTOR OPERATED GATE VALVES

Low Pressure — comp. geared — 38" — mfg by Chapman Valve Co. *MOTOR DATA:* H.P. 18 ft. lbs. running torque — 45 ft. lbs. max. starting torque — 440 volts 900 RPM 3 phase 60 cycle. Type: Submersible Valve Brake — Motor: Star Electric Co.
Also available, same as listed, but 36", and 28" inch as listed, but with smaller motor.

MISCELLANEOUS

18 WIDE-RANGE FORCED DRAFT TURBINE-DRIVEN BLOWERS

9 K.H. — 9 L.H. — mfg by B. F. Sturtevant — propeller fan type — capacity 29,500 CFM/5540 RPM/250 BHP — 8250# steam/hr. — and, 9,000 CFM/1985 RPM/9 BHP — 690# steam/hr. — 7 blades — static: max 35" water — normal 21.5" water. Driven by Sturtevant turbine type VC-7 — non-condensing — single stage — 250 HP — 575# steam pressure — 15# PSIG exhaust pressure.

1250 K.W. WESTINGHOUSE TURBO-GENERATORS

(4) — Westinghouse—440/3/60 — 850° — 540 lbs. working pressure. Complete with condensers, circulating pumps, etc.

LUBE OIL COOLERS

4 — mfg by Westinghouse. 1600 sq. ft. cooling surface — cylindrical straight-tube horizontal type. Oil capacity 590 GPM — water capacity 1500 GPM — temp. oil inlet 150°F — outlet 120°F — temp. water inlet — 85°F — outlet 90°F. Number of 5/8" tubes 816 — Wall 0.049 TK — Cupro Nickel.

MAIN CONDENSERS

Mfg. by Foster-Wheeler — 23,500 sq. ft. cooling surface — 40,500 GPM circulating water — total tubes 8,976, of cupro-nickel, as follows: (550) each 5/8" x 0.06e and (8416) each 5/8" x 0.049. Monel water boxes.

BOILERS

7 B&W EXPRESS TYPE

Design pressure 634# — operating pressure 565# — temp. 850°F. Oil fired — separately fired superheaters. *Capacity:* 210,000 lb. steam/hr. Ideal for testing where large quantities of steam are required, giving excellent control from separately fired superheaters.

3 GLAND EXHAUST CONDENSERS

Foster-Wheeler — total capacity lbs./hr.: 1200 lbs. steam and 350 lbs. air — 155 sq. ft. — 4" ejector.

LARGE DEAERATING FEED HEATERS

Monel construction — spray type — capacity 480,000 lbs./hr. — vent condenser — single pass — heating surface 174 sq. ft. — all Monel construction.

GE HIGH AND LOW PRESSURE MAIN PROPELLING TURBINES

WILL SELL SEPARATELY FOR TESTING, WIND TUNNEL OR SIMILAR WORK. *(2) High pressure* — 24,400 HP — 12 impulse stages — 4909 RPM — working pressure 540# — 825°F. *(2) Low Pressure:* 28,600 HP — 3913 RPM — working pressure 49# steam — 424°F — 2-6 stages of impulse.

THE BOSTON METALS COMPANY

313 East Baltimore Street
Phone: ELGIN 5-5050

Baltimore 2, Maryland
Phone: LEXINGTON 9-1900

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"For BIGGER SAVINGS and BETTER SERVICE, Get Our BARGAIN PRICES on Guaranteed NEW and REBUILT MOTORS"

SQUIRREL CAGE MOTORS
NEW AND GUARANTEED REBUILT

HP	Make	Type	Speed
500	L.A. B.B. Splash. 440 Volt	FX-1468	3600
500	G.E. S.B. Open	IK	1200
400	L.A. B.B. Splash		1800
400	G.E. S.B. Open	IK	1200
400	West. S.B. Open	CS	900
400	G.E. S.B. Open	IK-17B	900
400	West. S.B. Splash 2800 Volt	CS-89B	720
300	G.E. S.B. Open	IK	1800
300	G.E. S.B. Open	IK	900
300	G.E. S.B. Open	IK	720
300	G.E. S.B. Open	IK	600
300	West. S.B. Open	CS-1002	600
250	El. Dyn. T.E.F.C.B.B.	KNX	1800
250	G.E. S.B. Open	KT	1800
250	West B.B. Splash	CS-875	1800
250	G.E. S.B. Open 2200 Volt	IK-18	1200
250	G.E. S.B. Open	IK	1200
250	G.E. S.B. Open	IK	900
250	G.E. S.B. Open	IK	720
200	West S.B. Open	CS	1200
200	G.E. S.B. Open	IK-15	1200
200	G.E. S.B. Open	IK-15S	1200
200	G.E. S.B. Open 2200 v.	IK	1200
200	G.E. S.B. Open	IK	900
150	LA TEFCBB	JX-114	3600
150	G.E. S.B. Drip	K-8824	1800
150	West. S.S.B. Open	CS-771.1	1800
150	West. S.S.B. Open	CS-761C	1800
150	Al. Chal. B.B. Open	AR	1800
150	West. S.B. Open 2200V	CS	1800
150	G.E. S.B. Open	IK	1800
150	G.E. B.B. Open	KT	1200
100	West. TEFCBB	CS-8120	1200
150	West. B.B. Open	CS-772	1200
150	F.M. B.B. Open	H-24A	900
150	G.E. S.B. Open	IK	900
150	G.E. S.B. Open	KT-558	900
150	G.E. S.B. Open	IK	720
125	G.E. TEFCBB	K	3600
125	Burke B.B. Open 440 Volt	N-505	3600
125	Cont. TEFCBB XP	AP-100	1800
125	G.E. S.B. Open	IK	1800
125	West. S.S.B. Open	CS	1800
125	Al. Chal. B.B. Open	AR	1800
125	West TEFCBB	CS855	1200
125	G.E. S.B. Open	KT-558	1200
125	G.E. S.B. Open	IK	1200
125	G.E. B.B. Open	KT-353	1200
125	F.M. B.B. Open	H	900
125	G.E. S.B. Open	IK	720
125	G.E. S.B. Open	IK	600
100	Cont. TEFCBB XP	AP-505	1800
100	West. TEFCBB	CS-753	1800
100	G.E. S.B. Open	KT-343	1800
100	G.E. B.B. Open	K-504	1800
100	LA TEFCBB	JX-113	1800
100	West. TEFCBB	CS-770	1200
100	G.E. S.B. Open	KT-347	1200
100	West. SSB Open	CS-607	1200
100	F.M. B.B. Open	H20C	900
100	F.M. B.B. Open	H	720
100	F.M.B.B. Open	H	600
75	West. B.B. Open	CS-505	1200
75	West. S.S.B. Open	CS-505	1200
75	F.M. B.B. Open	H	900
75	F.M. B.B. Open	H	600
60	West. TEFCBB	CS-445	3600
60	G.E. TEFCBB	KF-445	3600
60	L.A. TEFCBB-XP	EX-445	3600
60	L.A. TEFCBB	JX-445	3600
60	West. TEFCBB	CS-445	1800
60	Cont. TEFCBB	NP-504	1800
60	G.E. TEFCBB	K-504	1800
60	West. TEFCBB	CS-505	1800
60	G.E. S.B. Open	K-444	1800
60	West. B.B. Open	CS-444	1800
60	West. S.S.B. Splash	CS-445	1800
60	Wagner TEFCBB	CP-445	1800
60	G.E. B.B. Open	K-444	1800
60	G.E. S.B. Open	KT-383	1800
60	G.E. S.B. Open	K-444	1800

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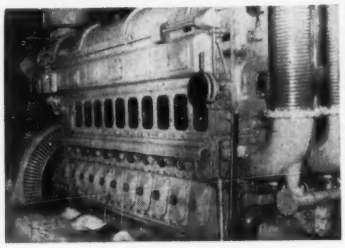
1000kw FAIRBANKS-MORSE
DIESEL ENGINE GENERATOR SETS



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Immediate delivery from stock.

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600 HP West. DC 230V 150-190 RPM
4—1200 KW Allis Chal DC 525V 720 RPM
17—1500 HP West (new) DC 525V 600 RPM

AC 3 PH 220/440V INPUT MG SETS

600HP GE/1750/42KW 250V DC 4 B.B. $1000
100HP West/1175/65KW 120V DC 4 B.B. $2000
125HP Elec Prod/1160/75KW 150V DC 4 B.B. $1750.
250HP West/1200/150KW 125V DC $2500

TURBO GENERATORS

60 KW West. DC/120V 200 PSI $1,500
100 KW AC/440V with Terry 150 PSI $1,500
250 KW GE AC/ 440V 525 PSI $3,000
2—540 KW West. DC/ 120-240V 590 PSI $3,000 ea.
1250 KW West. AC/ 440V 525 PSI $6,500

ALBERT HELLER'S SHIP SUPPLY CORP.
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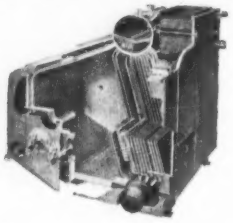
ULster 5-8643

BOILERS NEW UNASSEMBLED



# Steam/hr.	Key	PSI	Temp.
122,500	DF	565	850
121,650	DF	565	850
60,000	SF	435	750
74,000	H	280	500
55,000	A	240	—

DF Double Furnace, SF Single Furnace (illustrated), bent water tube boilers w/economizers and superheaters, B & W's and Foster Wheelers.

H Header type, straight tube, B & W.

A 3 drum, single furnace, Wickes.

Pelnik-Loconti Industrial Supply, Inc.
315 Oriskany St., Yorkville, N.Y.
Utica, N. Y. Ph. RE 6-4621, RE 2-4513

G.E. 1500KW TURBO GENERATOR COMPLETE WITH ALL AUXILIARIES

GENERATOR — 1500KW — 480 Volts — 3 Phase — 0.8 PF — 3,600 RPM — Totally enclosed — Surface Air Cooler — Direct-connected exciter.

TURBINE—Serial #72598—Designed to NEMA standards for 400 lbs. per sq. inch gauge, 750° F.T.T. 2 inches of mercury absolute back pressure. Presently equipped for 200# steam. Automatic extraction for low pressure heating system.

CONDENSER—1500 sq. ft. Ingersoll-Rand Surface Condenser with Integral Air Cooler, Steam Jet Air Ejector.

AUXILIARIES — Switchboard Panel with controls, metering, 3,000 Amp. Air Circuit Breaker—all pumps for condensate and circulating water—all valves and accessories—original construction drawings.

Unit in good operating condition—had limited operation—installed 1948, North Ohio Location. Available for inspection.

FS-3025, POWER
Class. Adv. Div., P.O. Box 12, N. Y. 36

375 KVA VERTICAL SKINNER — GE UNAFLOW GENERATING UNIT

One 14 x 12 Skinner 3-Cylinder Vertical Unaflow Engine direct connected to 375 KVA (300 KW @ 8 PF) GE 120/208 3-phase, 4-wire AC Generator 400 RPM with 10 KW GE Exciter for immediate shipment.

FRANK M. BEESON
Steam Plant Headquarters
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Telephone: RE 5-9820—or Western Union

TRANSFORMER & PANEL

1500 KVA 4160 to 480V 3 phase Westinghouse type SL
Inerteen filled transformer 4-2½% taps.
Westinghouse distribution panel DB50—3 pole breakers.
2000 a main bus—2-1200A 6-600A branch.

INDUSTRIAL ELECTRIC & SUPPLY CO.
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ALL TYPES OF FANS & BLOWERS
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TU 2-1706

COMPLETE MODERN 400 LB. POWER PLANT

3750 KVA Elliott Turbine Generator—563 H.P. Wickes Boiler 475 PSIG W.P.

Turbine is 440 PSIG 750° FTT Generator is 3/60/2400/4160. Surface Condenser and all auxiliaries.

This plant is complete in all respects and can be inspected as originally installed. Photographs, prints and specifications available

Other turbine Generators

1-1500 KW Westinghouse	525# 750° Non-Cond. 150# BP 2400V
1-2000 KW GE	600# 750° Non-Cond. 150# BP 4160V
2-3000 KW GE	600# 750° Non-Cond. 150# BP 2400/4160V
1-2500 KW Allis Chalmers	400# Autext 150° Non-Cond. 30# 480V
1-2500 KW Westinghouse	125# Non-Cond. 10# BP 2300V
1-2500 KW GE	400# 750° Autext 25# Condensing 600V
1-5000 KW GE	600# 750 Condensing 2300/4160
1-7500 KW Westinghouse	400# 750 Condensing 4160V

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DETROIT 35, MICHIGAN

Telephone: BRoadway 3-1900

DUAL FUEL & DIESEL ENGINE GENERATOR UNITS

1392 KVA Fairbanks Morse diesel engine generator unit 3 phase 60 cycle 2400 volts 300 RPM
Excellent condition

1250 KVA (2) Worthington supercharged diesel engine generator units 3 phase 60 cycle 2400/600/480 volts 360 RPM
New 1949 — Excellent condition

1050 KVA Nordberg supercharged diesel engine generator unit 3 phase 60 cycle 2400 volts 327 RPM
New 1947 — Excellent condition

The above units are still installed and can be adapted for Dual Fuel operation.

INTERNATIONAL POWER MACHINERY CO.
1612 Union Commerce Building—MAin 1-9514
Cleveland 14, Ohio

LIQUIDATION

COMPLETE OIL REFINERY DESTREHAN, LA.

Including

5—Babcock & Wilcox 70,000#/hr Superheated Steam Boilers, integral furnace type, 6188 sq. ft., 450# pressure complete with stacks, blowers, drives and accompanying set of instruments. (New 1952)
1—Ingersoll Rand 2 Stage Reciprocating Compressor, type 2-HHE-2, size 29½ x 17 x 12, 3170 cfm, 125# pressure with GE 600 HP 3/60/2300 V. motor. (New November 1958)
1—Carrier Centrifugal Blower, 3 Stage, 38,300 cfm, disch. press. 32.7#.
1—Carrier Centrifugal Compressor, 6 Stage, 9,370 cfm, disch. press. 124.7#.
1—Carrier Centrifugal Compressor, 3 Stage, 9,750 cfm, disch press. 93#.
190—Centrifugal Pumps, XP motor & turbine drives, up to 9000 gpm.

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HI-PRESSURE
Complete Stock from 10-3,000 h.p.
Nation's largest inventory, New & Used
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AUTOMATIC and MANUAL
Gas or DIESEL GENERATOR UNITS
Complete Switchboard Design and Construction
USED & REBUILT EQUIPMENT
UNIVERSAL POWER ENGINEERING CO.
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MODERN GE RECTIFIERS

3/60/13,200 AC to 600V. DC
4—1000KW Mod. 6RC-45-CD6
2— 500KW Mod. 6RG-45-CH2
Six Tube Ignitron Pump Type
Full Automatic AC & DC Controls

Can be inspected on original locations new in 1948, still like new, actual photos are available, very low price for lot.

S. M. DAVIS
525 N. 20th, E. St. Louis, Ill.

BOILER PLANT PRICED TO SELL

1—60,000# Hour Riley boiler, 290#s psi and 550 degrees F. Completely water walled with hopper bottom. Combination oil and pulverized coal burners, pulverizers, airheater, forced and induced draft fans with drives, Cinder collector, Bailey controls, completely steel encased. New generating tubes available. Related auxiliary equipment available.

MIDWEST BOILER & TURBINE CO.
520 5th Ave., New York 36, N. Y.

37 Years Dependable Service

SLIP RING MOTORS 3 Ph., 60 Cy.

H.P.	Volts	Make	Speed
500	4000/2300	G.E.	600
450	4000/2300	G.E.	1200
400	4000/2300	Whse.	720
300	4000/2300	G.E.	720
300	2300	G.E.	900
300	440	G.E. (hoist)	600
300	440	Whse.	3600
225	4000/2300	G.E. (hoist)	600
200	2300	G.E.	600
200	2200/440	G.E.	720
150	220/440	Whse.	720
125	2300	G.E.	600

AC GENERATORS or SYN MOTORS, 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
400	2300	G.E.	TS	1800
400	2200/440	G.E.	ATI	720
300	440/220	G.E.	TS	450
300	2200/440	G.E.	TS	1200
200	440	G.E.	TS	600
150	440/220	Whse.	G	1200
125	440/220	Whse.	HR	600

SQUIRREL CAGE MOTORS

500	2200/4000	Elliott	SC	1800
400	2300	G.E.	FT	3600
400	2300/4000	G.E.	K	1200
350	2300/4000	G.E.	SEDP	3600
350	2300/4000	G.E.	K	600
300(2)	2300	G.E.	FT	3600
300	2300/4000	L. Allis.	FS	1800
300	2300/440	G.E.	SEDP	1200
300	2300/4000	Cont'l.	Spl.-Prf.	720
300	2300/400	G.E.	KT	600
250	2300/4000	G.E.	K	720
200	2200	G.E.	KT	1800
200	2200	Cont.	TEFC	3600
150	440	Whse.	X-pf.	3600
150	440/220	Cont'l.	X-pf.	1800
150	440/220	G.E.	TEFC	720
150	2200/440		KT	600
150	2200/440	G.E.	FT	1200
125	2300/440	G.E.	K	600
100(2)	4000/2300	L. Allis.	OX	1200
100	2300	Cont'l.	TEFC	3600
60(2)	440	Cont'l.	X-pf.	1800

CIRCUIT BREAKERS, 3 Pole

4—1600 Amp., DA-50, Whse., 600 V., Air
1—600 Amp., Al. Chal., 15 KV, Outdoor
6— 600 Amp., R. Smith, 7.5 KV, Sol. oper.
1— 400 Amp., R. Smith, 7.5 KV, outdoor, New

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
150	230	El. Dyn.	B/brg.	800
60/75	230	G.E. (new)	CD	500/1500
50/60	230	Rel.	T	600/1800
50	230	G.E.(4)	CD	1150

MOTOR GENERATOR SETS

KW	Make	Input., AC	Motor Type	Output V., DC
300	Whse.	4150/400	Syn.	250/125
125	G.E.	440/220	Sq. Ca.	125
125	G.E.	440	Sq. Ca.	250/125
100	G.E.	2200/440	Syn.	250
75	Cr. Wh.	440/220	Sq. Ca.	240/120
70	El. Dyn.	440	Sq. Ca.	70
65	G. E. B	2200/440	Sq. Ca.	250

TRANSFORMERS 60 Cy.

1—500 kva, Al Ch. 2400/4160Y—600 volts, 3 ph.
3—500 kva. G.E., 13800—2300 V.
3—500 kva, G.E., 13800—240/480 V.
3—333 kva, American, 2400—240/120 V.
1—200 kva, G.E., 2400—120/240 V., Pyr.
3—200 kva, Mol., 13,800—2300 V.
3—200 kva, G.E., 13,800—480 V.
3—200 kva, G.E. 4156—480/240 V.
3—167 kva, Whse., 4156—480 V.
3—150 kva, Al. Ch., 2400—220 V.
3—150 kva, G.E., 13,200—2300 V.
3—100 kva, Whse., 4800/2400-240/480 V., Dry
3—100 kva, G.E. 2400—120/240 V., Pyr.

GASOLINE—ENGINE GENERATOR SETS

2—35 kva, 900 R. 230 V, 3 ph. con. LeRoi, 6 cyl.
only partial listing

STEPHEN HALL & CO.
HARRY J. RICE, Pres.
625 ADAMS ST., HOBOKEN 2, N. J.

BOILERS

BOUGHT SOLD RENTED

2—50,000 lbs. hr. Combustion Engineering 250 lbs. press—1950
2—600 H.P. B & W Sectional Steel Headers—200 lb. press
1—300 H.P.—15 lb. press Superior Package
1—200 H.P.—15 lb. press Cyclotherm
1—125 H.P. Dowtherm — Cleaver — Brooks
Cyclotherms 15- 30- 50- 90- 125- 200 H.P.
Cleaver—Brooks—50- 70- 80 H.P.
Waste—Heat Boiler—200 H.P.—250 lbs.

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ULSTER 5-3588

BOILERS

BOUGHT AND SOLD

Specially Babcock & Wilcox sect. headers or sterling type, all sizes.

ARG CHEMICAL MACHINERY
507 Fifth Avenue, New York, N. Y.

WANTED

Turbo-Generator

3500-7500 KW, 2300/4160 V - 3/60
400 psi @ 600F Condensing

K. E. Bovay, Jr., Consulting Engineers
5009 Caroline, Houston 4, Texas

TRANSFORMERS—60 CYCLE

Qu	KVA	Make	Type	Phase	Voltages
2	3000	Moloney	TCR	3	7200/6600-4160/2400
2	750	G.E.	K	1	4600-120/240
1	300	Penna.	(Askarel)	3	12470Y/7200-240
2	250	G.E.	H Pyranol	1	4800/3330Y/120/240
3	250	West.		1	2300/4600-220/460
3	200	G.E.	HBW2F	1	2400/4160-240/480
3	200	Amer.	CC	1	4160/7200-240/480
6	100	West.	Hypersil		2400/4160-120/240
3	75	G.E.	KF	1	2400/4160-120/240
3	50	G.E.	H	1	2400/4160-240/120
1	50	Amer.	Abestol	3	4160-120/208Y
4	25	West.	Hyperail	1	2400/4160-120/240

MOTOR GENERATOR SETS

Qu	KW	Make	Speed	DC	AC
1	75	EM	1200	250	Syn. 220V.
1	75	G.E.	1200	125	2300/4160 Syn.
1	100	West.	1200	250	2300/4160Y Syn.
1	175	West.	1200	125	4150 Syn.
1	300	G.E.	1200	250	2300/4160Y SR
1	300	G.E.	1200	250	440 Syn.
1	1000	West.	720	600	2300/4160Y

ENGINE GENERATOR SETS

1—Hercules Gas HXE 62.5 KVA Wentghe 3/60/480—1200
1—Wisconsin Gas (Air) PE-99 7.5 KVA Master 1 or 3/120—2200 r.p.m.

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
2	40	West.	600	CW	220/440
1	60	G.E.	1800	MT	220
1	60	G.E.	860	MT 546	440
1	75	G.E.	600	IM	440
1	100	West.	1800	T.E.F.C. B.B.	220
3	150	Allis-Ch.	1800	AY-RW	2300
1	200	West.	514	CW	440
1	250	West.	600	CW	440
1	350	West.	1800	CW	2300
1	450	West.	1800	CW-4-20-9, 220 or 440	
1	500	G.E.	450	MT	2300
1	500	G.E.	1200	M369Z	2300/4160Y

D. C. MOTORS—230 VOLTS

Qu	HP	Make	Speed	Type
1	350	G.E.	1200	Pedestal
1	92	West.	425/1000	SK 113
1	30	G.E.	1750	173 FR
1	30	West.	690/1400	SK-4G1543

SQUIRREL CAGE MOTORS, 3 PHASE, 60 CYC.

1—300 HP, 1200, Allis. Chalmers, 2300/4150Y
1—275 HP, 1130 RPM G.E. Type KT 559BS 2200V
2—200 HP, 1790 RPM, G.E. Elec. KF, TEFC, 2300V
1—100 HP, 1775 RPM G.E. KTP-543 3Ø 60-440V.

MOTORS—SYNCHRONOUS—3 ph. 60 cy.

100 HP 900 RPM G.E. Fom BL 2200 V.
125 HP 600 RPM G.E. Type TS 2200 V.
125 HP 900 RPM G.E. Type TS 4800 V.
150 HP 3600 RPM G.E. type TS Fr. 956Y 2200 V.
150 HP 1800 RPM G.E. Type TS 220 V.
300 HP 720 RPM Elec. Machinery t.e.f.c. 2300 V.
325 HP 900 RPM West—2300 V.
400 HP 450 RPM Westinghouse Type HR 440 V.

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PHONE NEW JERSEY—UNION 5-7600

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COOPERATIVE CREAMERY ASSN.
BONGARDS, MINNESOTA.

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2. 450 hp 6 cyl. direct connected to FM 375 kva Alternator.
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Director of Plant Operations
Vassar College, Poughkeepsie, New York

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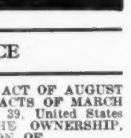

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Long Distance Phone LD: 133

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1—6000 kva G.E. 3/66000/2400/4160Y
1—2000 kva Nia. Askarel. 3/13800/4160Y/2400
3—1000 kva Westinghouse, 1/22900/480
3—1000 kva Westinghouse, 1/13800/480
3—1000 kva Westinghouse, 1/13800/2400/4160Y
3—1000 kva Standard, 1/44000/6900
3—1000 kva Standard, 1/69000/4160Y/2400
3—1000 kva Standard, 1/34400/480
3—833 Allis Chalmers 1/60/12,000-480
3—200 kva Westinghouse, 4800—240x480
3— 100 kva G.E., 2400/4160Y—120x240
3— 75 kva G.E., 2400/4160Y—120x240

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3—1296 HP B&W Sectional Steel Headers 275 PSI Gas/Oil Fired
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1—1875 KVA Condensing 400 PSI 700°F with Surface Condenser 3/60/2300 Turbo Set
1—500 KW Condensing 200 PSI Turbine
1—500 KW G.E. Non Condensing 265 PSI, 0-10# BP Turbo Generator

TRANSFORMERS

1—6000 KVA 3/60/44,000—4160 Substation
1— 750 KVA 3/60/2400/4160 Y—480
3— 333 KVA 1/60/2400/4160 Y—480

A. C. MOTORS — 3 ph. 60 Cy.

Qu.	HP	Make	Type	Speed	Volt
2	2000	A.C.	ANW	1750	2300
2	350	A.C.	AZZ TEFC X.P.	3600	2300
1	250	Cont.	NP TEFC X.P.	720	2300
1	200	G.E.	KF TEFC X.P.	3600	2300
1	125	Cont.	NP TEFC X.P.	3600	2300
1	125	G.E.	KF TEFC X.P.	1800	2300
3	100	G.E.	K TEFC X.P.	1800	440
1	150	West.	CW Slip Ring	1800	440
3	75	West.	CW Slip Ring	1800	440
3	30	West.	CW Slip Ring	1200	440
1	400	G.E.	TS Sync.	1800	4160

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POWER EQUIP. DIV.

60 East 42nd St., New York 17, N. Y.

310 Thompson Bldg., Tulsa 3, Okla.

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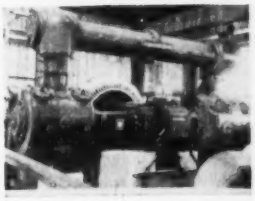
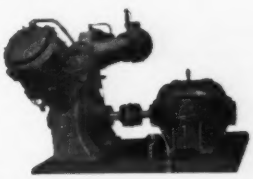
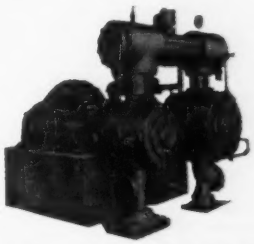
931 CFM Displacement 55# 277 RPM. 17 x 13 Rebuilt Ingersoll-Rand ESE-I, Timken bearing, horizontal, single stage, water-cooled, double acting air compressor equipped with: Free air unloading, Mechanical lubricator, DIRECT CONNECTED TO: 125 HP, 277 RPM unity power factor, 3/60/440 volt synchronous motor with rotor mounted on crankshaft of compressor complete with exciter and automatic starter equipment. Foundation plan.



3798 c.f.m. Displacement 125# **INGERSOLL-RAND** type 2-HHE-2 two stage air compressor. 29½—17x12. 600 H.P. G.E. sync. motor 3/60/2300. 1957 compressor—ran 56 hours, crane and building available.



691 CFM Displacement 100# 690 RPM. 13½/8 x 7 Flange mounted Chicago-Pneumatic Type "VCM" vertical angle, double acting, heavy duty air compressor equipped with: 3-step control; Mechanical force feed lubricator; Pressure lubrication for running gear; Intercooler with safety valve & gauge; Enclosed frame FLANGE MOUNTED TO: 100 HP General Electric TS 600 RPM unity power factor 3/60/440 volt synchronous motor with CR-7065H5E starter and M.G. set; Aftercooler.



1545 CFM Displacement 80-110# 277 RPM. 21/13 x 14 Used **Ingersoll-Rand XRE**, two stage, double acting, duplex, water-cooled, heavy duty, horizontal, synchronous motor driven air compressor equipped with: Step control; Mechanical force feed cylinder lubrication; Automatic frame oiling system; Intercooler with safety valve & pressure gauge. DIRECT CONNECTED TO: 250 HP General Electric 277 RPM unity power factor 3/60/220 or 440 volt engine type synchronous motor complete with starter and exciter. Air Receiver.

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UNion 5-4848

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Canton, Mississippi

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2400 V, 3600 RPM, 200 PSI

5000 KW, West. Non-Condensing
2500 V, 3600 RPM, 850 PSI
850°—150# B.P.

1000 KW, Worth-Moore, Cond. Ext.
245/490V, 130-300# I.P., 10# Ext.

625 KW, West. Non-Condensing
480V, 3600 RPM, 200 PSI, 12-15# BP

500 KW, West. Condensing
480V, 3600 RPM, 200 PSI, 15-30# Ext.

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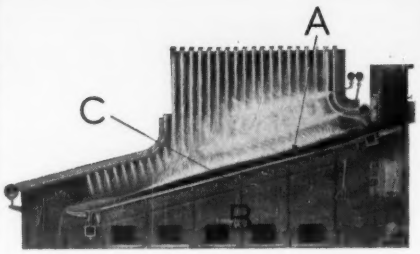
The only preventive maintenance required on a Vibra-Grate Stoker is for a mechanic to grease it every three months at four points on the front.

AT SPAULDING FIBRE COMPANY
(makers of ARMITE, SPAULDITE fibres and plastics)

Vibra-Grate Stokers save 1000 tons of coal per year!



With AE Vibra-Grate Stoker, intermittent agitating action feeds coal down inclined grates (**A**) at controlled rate. This automatically levels fuel, eliminates spotty burning. Separate zones (**B**) permit exact adjustment of forced draft air for proper combustion at all stages of burning. Water-cooled grates (**C**) virtually eliminate maintenance. Stoker feeds wet or dry coal of any grade. Water-cooled grates permit burning gas or oil without damage to grates. Quick conversion from or to coal now possible.

The two 50,000-lb AE Vibra-Grate Stokers shown above went on line at the Tonawanda plant of the Spaulding Fibre Company in 1958.

Cost and performance data for the two-year period to January 1960 are reported as follows:

Total coal consumption (both units), 26,472 tons; an estimated savings of 2,000 tons compared with other stokers in the same plant. Superior air zoning increases combustion efficiency at all loads. Average evaporation on one unit is 10.6 lb of steam per pound of coal and 10.8 on the other, using coals having an average Btu value of 13,173.

To cap it off, the company reports maintenance costs are much lower than those of other types of stokers in service, and . . . "efficiency and operating economies far in excess of the manufacturer's guarantee and our highest expectations."

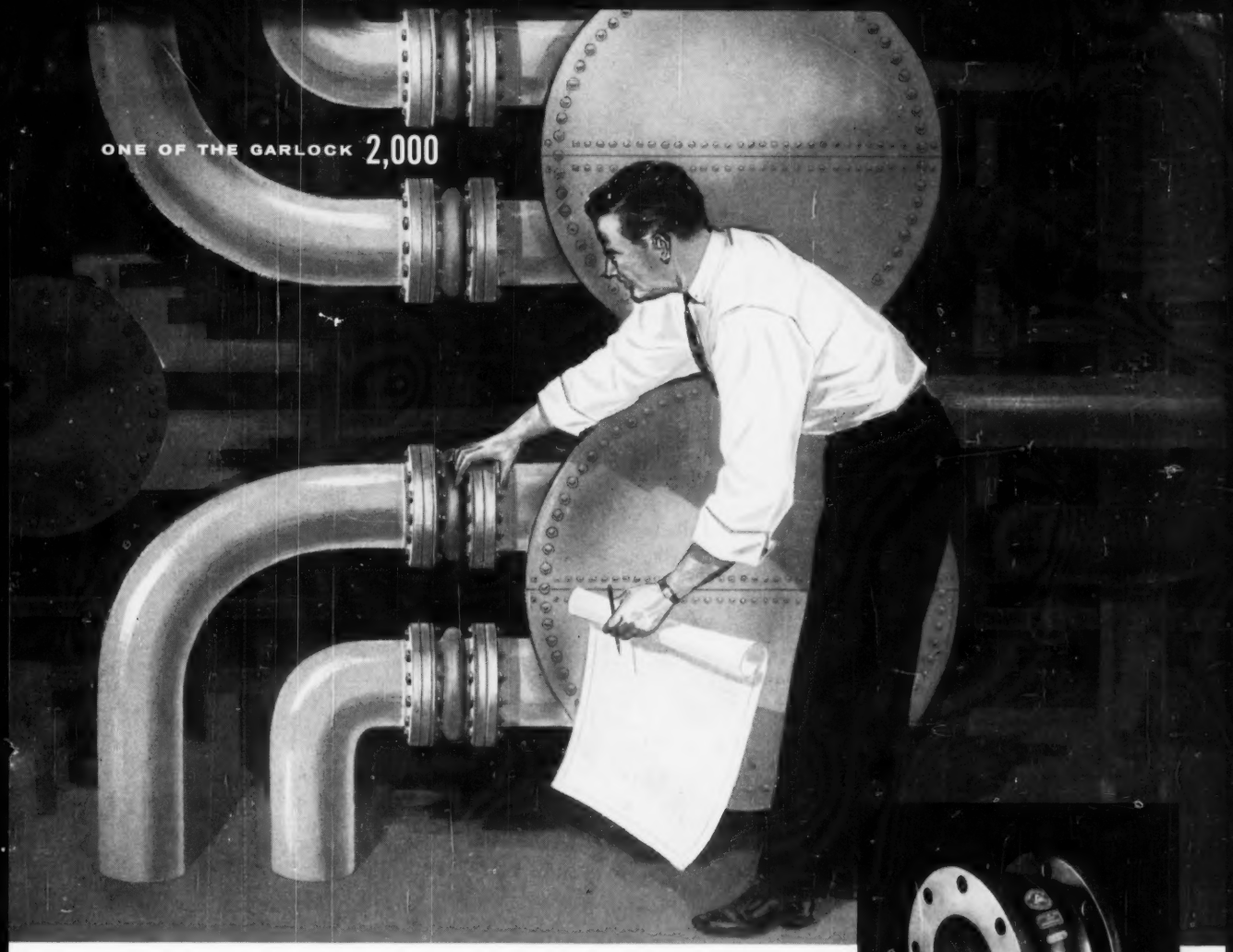
In every installation, and under the most critical observation, time and usage are proving the peak efficiency, and the almost total elimination of maintenance costs, possible with the exclusive AE Vibra-Grate Stoker design. No other stoker combines the advantages of vibrating grate feed, water-cooled grates and precision-controlled air zones.

Write to Dept. S-101 for copies of plant operating reports and AE Vibra-Grate Stoker Catalog S-546-A today.

AMERICAN ENGINEERING COMPANY
Wheatsheaf Lane & Sepviva St. • Philadelphia 37, Pa.

Canadian Subsidiaries: Affiliated Engineering Corporations, Ltd., Montreal, P. Q. • Bawden Industries Ltd., Toronto, Ont.

For more facts circle 332 on Reader Service card, p 123



4 Reasons Why It's Good Piping Practice To Use Garlock Rubber Expansion Joints

1. **PREVENT STRESSES.** Piping systems expand and contract with temperature changes. Garlock Expansion Joints act as a "breather" . . . compensate for expansion and contraction.
2. **ELIMINATE VIBRATION AND NOISE.** Pumps, compressors, engines, and pressure surges in pipe lines create vibration and objectionable noises. Garlock Rubber Expansion Joints act as an absorbent cushion . . . reduce vibration and insulate against transfer of noise to other parts of the building.
3. **COMPENSATE FOR MISALIGNMENT.** Piping and mechanical equipment often moves out of normal alignment during operation due to wear, load stresses, or settling of buildings. Garlock Rubber Expansion Joints compensate for this and prevent possible breakdowns of equipment. They also make installation easier since alignment of piping and equipment need not be quite as accurate when expansion joints are used.
4. **REDUCE FLANGE BREAKAGE.** Undue stress caused by misalignment, vibration, expansion or contraction of piping or equipment, will break the metal connecting flanges. Garlock Rubber Expansion Joints relieve such stresses.

AND, remember Garlock Rubber Expansion Joints do not crack, corrode, lose shape, or require gaskets. Available for pressures up to 125 psi. Maximum service life at temperatures to 180° F. Get complete data on this important member of "the Garlock 2,000" . . . two thousand styles of packings, gaskets, and seals for every need. See your local Garlock Representative or write for folder AD-137.

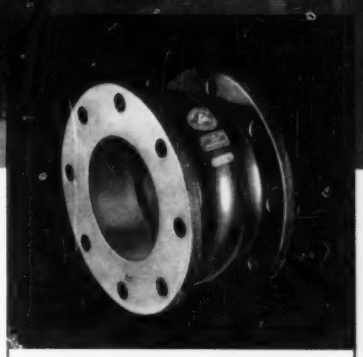
The Garlock Packing Company, Palmyra, N. Y.

For prompt service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

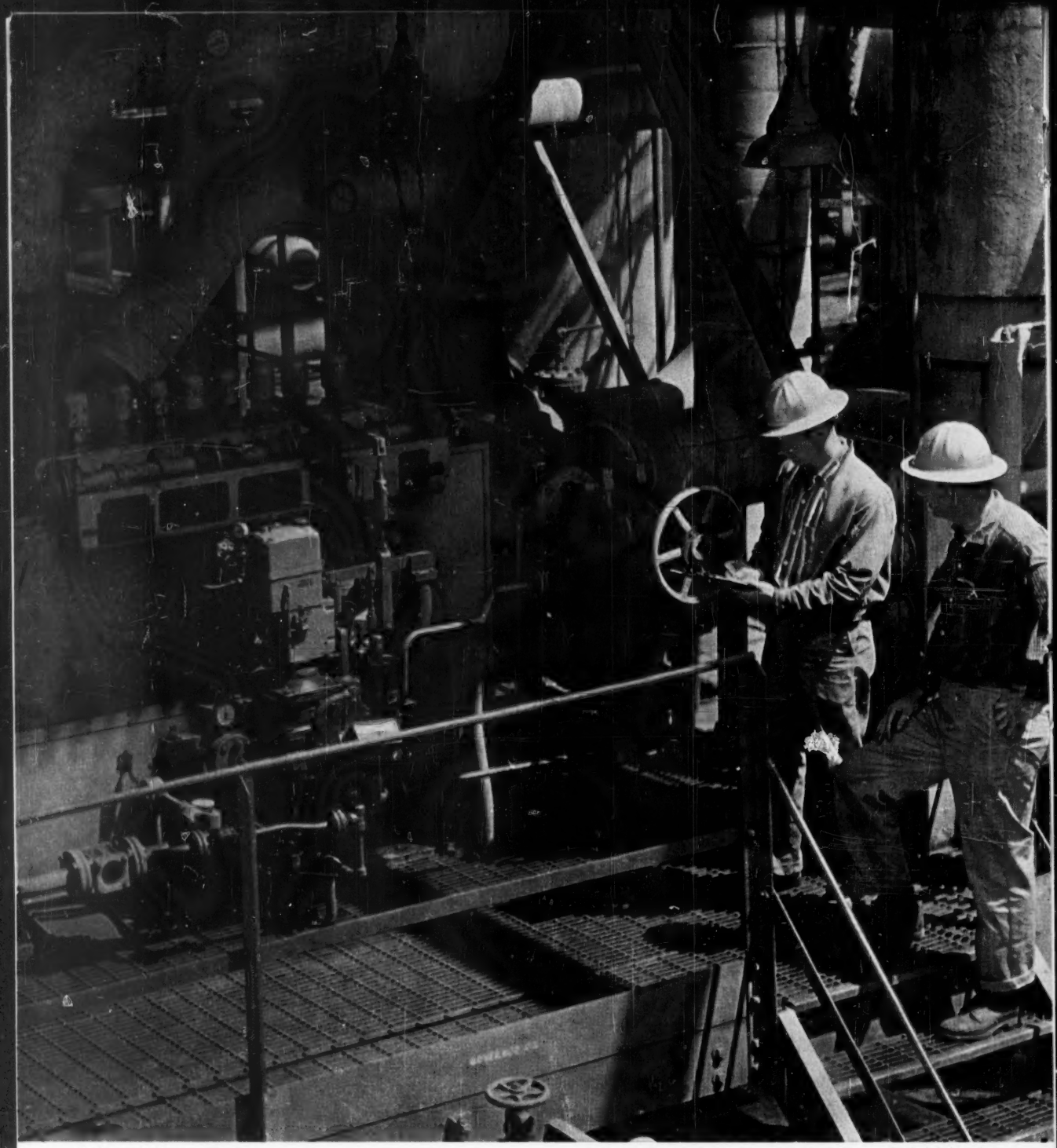
Canadian Division: The Garlock Packing Co. of Canada Ltd., Plastics Division: United States Gasket Company



TYPICAL APPLICATIONS FOR GARLOCK RUBBER EXPANSION JOINTS

- Air Conditioning Systems
- Air Ducts
- Air Injection Lines
- Ballast Lines of Ships and Barges
- Blower Lines
- Brine Tanks
- Dry Vacuum Lines
- Connecting Turbines and Condensers
- Jet Condensers
- Paper Stock Lines
- Pump Lines, Discharge and Suction
- Ventilating Systems
- Chilled Water Lines
- Hot Water Lines to 180° F.
- Circulating Water Lines to Condensers

For more facts circle 202 on Reader Service card, p 123



1650 hp, 6783 rpm Worthington turbine driving a centrifugal compressor at Gulf Oil Corporation's Girard Point Refinery, Philadelphia, Pa.

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You'll find an interesting message about Worthington compressors on page 33 of this issue of POWER.